PRECISION

HOLT
INSTRUMENT
LABORATORIES
OCONTO WISCONSIN

MEASUREMENT

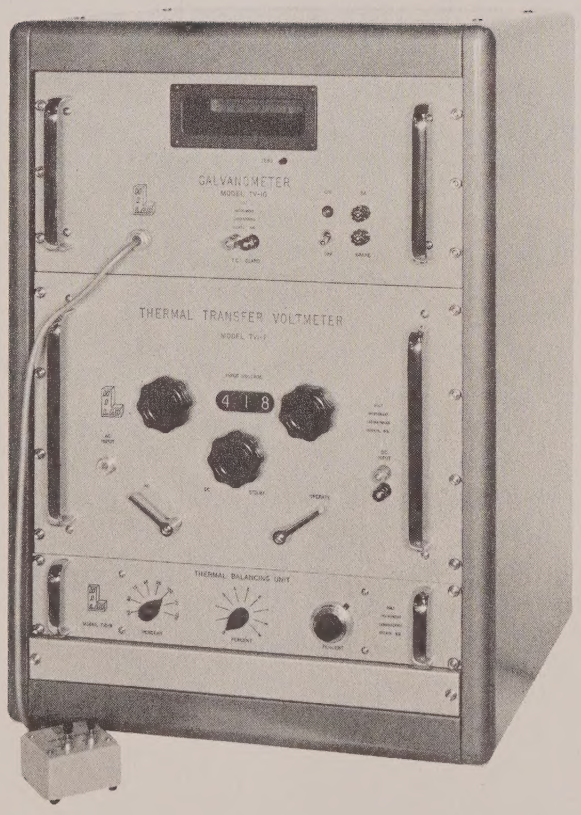
# OPERATING & SERVICING MANUAL

# FOR

# THERMAL TRANSFER

# STANDARD

# MODEL TV-1




THIS MANUAL TO ACCOMPANY
INSTRUMENT No. 804/

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

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# ADDENDUM - TABLE OF REPLACEABLE PARTS

HOLT INSTRUMENT LABORATORIES
Oconto, Wis.

September, 1961

NOTE: This addendum to accompany all manuals with Holt Instrument Labs Model TV1, subsequent to serial Number 8032.

The following parts may be installed in place of those currently listed in the manual parts list or on the drawings. The below listed components may deviate slightly in ohmic value, but will have no noticeable effect on the instrument, its function, or any of its circuits.

| CKT. REF. | DESCRIPTION | HOLT NO. | MFR. & MFRS DESIGNATION |
|---|---|---|---|
| R-221 | Resistor, Fixed, Deposited Carbon, 2.74 KΩ, 1/2 Watt, ± 1% | 10003-272 | IRC DCC RN 20X |
| R-223 | Resistor, Fixed, Deposited Carbon, 4.32 KΩ, 1/2 Watt, ± 1% | 10003-432 | IRC DCC RN 20X |
| R-319 thru R-325 | Resistor, Fixed, Deposited Carbon, 30.1 KΩ, 1/2 Watt | 10003-303 | IRC DCC RN 20X |
| Z-201 | Thermo-Couple Module | 81720 | |

The following parts are part of Z-201

R-203

R-227

R-228

R-229

PARTS REMOVED

XL-7035

| ITEM | CIRCUIT REF. | DESCRIPTION | MFR. & MFRS DESIGNATION | HOLT NO. | QT |
|---|---|---|---|---|---|
| 30 | R-102 | Resistor, Fixed, Metal Film, 142.5 Ohms, 1 Watt, ± .25% | DA 851N-142.5 | 10000-141 | 1 |
| 31 | R-103 | Resistor, Fixed, Metal Film, 285 Ohms, 1 Watt, ± .25% | DA 851N-285 | 10000-281 | 1 |
| 32 | R-104 | Resistor, Fixed, Metal Film, 428 Ohms, 1 Watt, ± .25% | DA 851N-428 | 10000-421 | 1 |
| 33 | R-105 | Resistor, Fixed, Metal Film, 570 Ohms, 1 Watt, ± .25% | DA 851-570 | 10000-571 | 1 |
| 34 | R-106 | Resistor, Fixed, Metal Film, 714 Ohms, 1 Watt, ± .25% | DA 851-714 | 10000-711 | 1 |
| 35 | R-107 | Resistor, Fixed, Metal Film, 857 Ohms, 1 Watt, ± .25% | DA 851-857 | 10000-851 | 1 |
| 36 | R-108 | Resistor, Fixed, Metal Film, 1000 Ohms, 1 Watt, ± .25% | DA 851-1000 | 10000-102 | 1 |
| 37 | R-109 | Resistor, Fixed, Metal Film, 1142 Ohms, 1 Watt, ± .25% | DA 851-1142 | 10000-112 | 1 |
| 86-94 & 110 | R-301 to R-304 & R-326 | Resistor, Fixed, Metal Film, 300 K Ohms, 1/2 Watt, ± .25% | DA 850-300K | 10004-304 | 10 |

PARTS ADDED

XC-7035

| REPLACES ITEM | CIRCUIT REF. | DESCRIPTION | MFR. & MFRS DESIGNATION | HOLT NO. | QTY UNI |
|---|---|---|---|---|---|
| 30 | R-102 | Resistor, Fixed, Metal Film, 142.8 Ohms, 1/2 Watt, ± .25% | DA DA-2-142.8 | 10074-141 | 1 |
| 31 | R-103 | Resistor, Fixed, Metal Film 285.7 Ohms, 1/2 Watt, ± .25% | DA DA-2-285.7 | 10074-281 | 1 |
| 32 | R-104 | Resistor, Fixed, Metal Film, 428.5 Ohms, 1/2 Watt, ± .25% | DA DA-2-428.5 | 10074-421 | 1 |
| 33 | R-105 | Resistor, Fixed, Metal Film, 571.4 Ohms, 1/2 Watt, ± .25% | DA DA-2-571.4 | 10074-571 | 1 |
| 34 | R-106 | Resistor, Fixed, Metal Film, 714.3 Ohms, 1/2 Watt, ± .25% | DA DA-2-714.3 | 10074-711 | 1 |
| 35 | R-107 | Resistor, Fixed, Metal Film, 857.1 Ohms, 1/2 Watt, ± .25% | DA DA-2-857.1 | 10074-851 | 1 |
| 36 | R-108 | Resistor, Fixed, Metal Film, 1000.0 Ohms, 1/2 Watt, ± .25% | DA DA-2-1000 | 10074-102 | 1 |
| 37 | R-107 | Resistor, Fixed, Metal Film, 1143 Ohms, 1/2 Watts, ± .25% | DA DA-2-1143 | 10074-112 | 1 |
| 86-94 & 110 | R-301 to R-304 & R-326 | Resistor, Fixed, Metal Film, 300 K Ohms, 1/2 Watt, ± .25% | DA DA-4-300 K | 10084-304 | 1( |

REMOVE THE FOLLOWING:

| | | | | |
|---|---|---|---|---|
| R-111 | 10020-122 | DAVEN-852 | 1285 Ohms | .25% |
| R-112 | 10020-272 | DAVEN-852 | 2720 Ohms | .25% |
| R-113 | 10020-412 | DAVEN-852 | 4140 Ohms | .25% |
| R-114 | 10020-552 | DAVEN-851 | 5570 Ohms | .25% |
| R-115 | 10020-702 | DAVEN-852 | 7000 Ohms | .25% |
| R-116 | 10020-842 | DAVEN-852 | 8440 Ohms | .25% |
| R-117 | 10020-982 | DAVEN-852 | 9860 Ohms | .25% |
| R-118 | 10020-113 | DAVEN-852 | 11280 Ohms | .25% |
| R-119 | 10020-123 | DAVEN-852 | 12700 Ohms | .25% |
| R-121 | 10030-143 | SAGE-SS5W | 14150 Ohms | .25% |
| R-122 | 10030-283 | SAGE-SS5W | 28400 Ohms | .25% |

AND REPLACE WITH THOSE BELOW:

| | | | | |
|---|---|---|---|---|
| R-111 | 10097-122 | SAGE-SS7W | 1285 Ohms | .25% |
| R-112 | 10097-272 | SAGE-SS7W | 2720 Ohms | .25% |
| R-113 | 10097-412 | SAGE-SS7W | 4140 Ohms | .25% |
| R-114 | 10097-552 | SAGE-SS7W | 5570 Ohms | .25% |
| R-115 | 10097-702 | SAGE-SS7W | 7000 Ohms | .25% |
| R-116 | 10097-842 | SAGE-SS7W | 8430 Ohms | .25% |
| R-117 | 10097-982 | SAGE-SS7W | 9860 Ohms | .25% |
| R-118 | 10097-113 | SAGE-SS7W | 11280 Ohms | .25% |
| R-119 | 10097-123 | SAGE-SS7W | 12700 Ohms | .25% |
| R-121 | 10097-143 | SAGE-SS7W | 14140 Ohms | .25% |
| R-122 | 10097-283 | SAGE-SS7W | 28460 Ohms | .25% |

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FRONTISPIECE

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## CLAIM FOR DAMAGE SHIPMENT:

The instrument should be tested as soon as it is received. If fails to operate properly, or it is damaged in any way, a claim shou be filed with the carrier. Also, notify Holt Instrument Laboratories the local Representative immediately. A full report of the damage sh be obtained by the claim agent, and this report should be forwarded us. We will advise you of the disposition to be made of the equipm and arrange for repair or replacement. Include model number and ser number when referring to this instrument for any reason.

## WARRANTY:

Holt Instrument Laboratories warrants each instrument manufactu by them to be free from defects in material and workmanship. Our lia ity under this warranty is limited to servicing or adjusting any ins ment returned to the factory for that purpose and to replace any def tive parts thereof. Electron tubes, fuses and batteries are specific excluded from any liability. This warranty is effective for one ye after delivery to the original purchaser when the instrument is retu transportation charges prepaid, and when upon our examination it is our satisfaction defective. If the fault has been caused by misuse abnormal conditions of operation, repairs will be billed at cost. this case an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt Representative, giv full details of the difficulty, and include the model and serial num Upon receipt of this information we will give you service data or sh ping instructions.

2. On the receipt of shipping instructions, forward the instrumen prepaid to the factory or the authorized repair station indicated in instructions. If requested, an estimate of the charges will be made fore the work begins if such work is not covered by warranty. All s ments of Holt Instrument Laboratory equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

## NOTICE

The warranty in this manual, as applied to Holt Instrument Laboratories Model TVI, is null and void if the sealed section of the thermocouple module shows evidence of having been opened or tampered with.

If the thermocouple within the sealed portion of this module has failed or after testing, according to the appropriate maintenance procedure contained herein, the thermocouple is judged faulty, consult Holt Instrument Laboratories or its authorized representative for a replacement module.

# TECHNICAL SPECIFICATIONS

| | |
|---|---|
| RANGE: | TVI-T - 1 volt to 999 volts in 1 volt increments. |
| | TVI-B - Permits balances of from 50% to 130% with continous resolution. |
| | Combined units - .5 volts to 1300 volts with continous resolution. |
| FREQUENCY RESPONSE: | .5 to 299 volts - .02% to 50 KC |
| | 300 to 1300 volts - .02% to 20 KC |
| | Correction curves accurate to 0.1% to 5 MC are available for the following voltages 1, 2, 5, 10, 20, 50, 100, 200. |
| THERMOCOUPLE: | D.C. reversal error - Less than .02% |
| INPUT RESISTANCE: | All ranges - approximately 143 OHMS/volt. |
| NULL SENSITIVITY AND RESOLUTION: | At 120% input range setting - .003%/m.m. |
| | At 100% input range setting - .004%/m.m. |
| | At 60% input range setting - .009%/m.m. |
| PHYSICAL DIMENSIONS: | 3 units - 19" - rack mounted. |
| | TVI-G - 8 1/4" high, 13" deep. |
| | TVI-T - 14" high, 15" deep. |
| | TVI-B - 3 1/2" high, 7" deep. |
| POWER REQUIREMENTS: | 50 watts, 115 volts $\pm$ 10% 60 cps |

## I-1 DESCRIPTION

The Holt Model TVI is a Thermal Transfer Voltmeter consisting of three basic sub units: The Transfer Device; The Galvanometer Unit; and the Thermal Balance Unit. These three assemblies constitute a N.B.S. certifiable standard of sinousoidal alternating voltages operating over a wide range of frequencies. Measurement is made by equating the RMS magnitude of an alternating voltage to the magnitude of a direct voltage which will produce the same temperature in a heating element. This heating element is enclosed in a vacuum bulb with a thermocouple mounted at its midpoint to measure its temperature. This heater and thermocouple will be referred to below as the transfer thermo-element. The transfer thermo-element is preceded by suitable current limiting resistors, coaxially mounted for best frequency response. These resistors are front panel selected in three decades, in one volt increments, over the voltage range of the instrument. The D.C. to which you transfer is applied to the same circuit as the A.C. voltage being measured. Therefore, the absolute accuracy of the measurement is not a function of the absolute value of the resistors or of the ratio of resistors.

The temperature of the thermo-element is measured by a circuit consisting of a high resolution, sensitive galvanometer, critically damped, in a thermal bridge with a second, opposing thermo-element. The second thermo-element is driven by a calibrated, double zener-stabilized, D.C. power supply. This arrangement minimizes the effect of ambient temperature changes and

permits highly stable balances to be achieved and maintained over long periods of time.

The combination of the above described features plus the incorporation of a sensitive galvanometer permits the most accurate A.C. measurements with ease and simplicity.

1-2 DAMAGE IN SHIPMENT

Examine the instrument carefully upon arrival. If there is any apparent damage refer to "Damage In Shipment" in this manual for instructions.

1-3 POWER CABLE:

A three conductor power cord is supplied with the instrument terminated in a NEMA recommended, polarized, 3 prong male connector. The large rectangular pin should connect to the common side of the A.C. power line; the small rectangular pin to the hot side of the line. The chassis of the instrument is connected to the large round pin of the connector. It is important that this be connected to the ground connection and returned to earth with a minimum of noise. The instrument is designed for operation on power line voltage of 115 volts plus or minus 10% and at power line frequency of 60 cps. The TVI will consume approximately 50 watts of power.

1-4 SHOCK AND VIBRATION:

Since the TVI has within its chassis a galvanometer movement, care should be exercised in placement of the unit where it will not be subjected to mechanical shock or vibration. The unit will withstand considerable shock before damage will result, however, the slightest vibration will directly affect the accuracy and readability of the galvanometer.

## 2-1 TERMINALS AND CONTROLS:

On-Off Switch: This toggle switch applies power to the galvanometer light source and the D.C. power supply. When the on-off switch is on, the on indicator light will glow.

Fuses: The 1/2 ampere fuse on the right side of the TVI-G panel fuses all A.C. power to the unit. Immediately below is a spare fuse in a holder.

Galvo Zero: The small knob below the galvanometer bezel is a mechanical zero adjust controlling the zero position of the galvanometer light beam over a limited range. Additional mechanical adjustment may be obtained by removing the top of the galvanometer unit and rotating the cap of the galvanometer assembly in the proper direction.

TC-Guard Terminals: The two terminals in the center of the TVI-G panel are linked together for normal operation. However with the link removed, you may conveniently measure the bead leakage (heater to couple resistance) of the thermo-elements without removal from the instrument.

Galvo Control: Located on the portable galvo control box are keys marked coarse and fine. With neither key engaged the CXDR of the movement is connected across the galvo terminals. With the fine key down the galvanometer is connected directly into the thermo-couple temperature sensing circuit. The coarse key employs a resistive divider arrangement reducing the galvo sensitivity to 1/10th the fine sensitivity.

Thermal Balance Control Input Jack: On the right rear of the TVI-G is a three terminal connector receptacle. This receptacle receives the plug from the thermal balance control assembly.

Balancing Thermo-Element Controls: On the right rear side of the TVI-G are two screwdriver adjustments. These are the coarse and fine controls used in balancing the opposing thermo-element heater current. These should require adjustment only when the thermo- element is replaced.

Input Terminals: On the left of the TVI-T front panel is a UHF receptacle for the input of the A.C. voltage under test. On the right of the TVI-T front panel are the D.C. input terminals; red being voltage input and black is the common return.

Transfer Switch: The lever switch on the lower left of the TVI-T front panel connects one of the inputs to the thermo-element. In the A.C. position the A.C. terminals are connected and in the D.C. position the D.C. terminals are in the circuit. The terminals not selected are open circuited.

Standby-Operate: The lever switch on the lower right of the TVI-T front panel opens the thermo-element circuit in standby and engages it in operate. This control also locks the input voltage range dials when in operate and must be returned to standby to change the range.

Input Voltage Range Dials: The cluster of three dials in the center of the TVI-T front panel are used to select the desired input voltage range. They directly control the selection of the proper current limiting resistor to be placed in series with the thermo-element. This is accomplished in three decades; 100 volt increments with left knob; 10 volt increments with the center

knob and 1 volt increments with the right knob. The voltage range selected appears in the center window and is variable in 1 volt increments from 1 volt to 999 volts.

Thermal Balance Controls: The three controls located on the thermal balance unit front panel determine at what percentage of the input voltage range setting the unit is being operated. They control the current in the compensating thermo-element. The left knob does this in 10% increments from 50% to 120%. The center knob does so in 1% increments from zero to 9% and the right knob controls a ten turn continuously variable potentiometer at .1% per full revolution.

2-2 OPERATION - A.C. TO D.C. TRANSFER TECHNIQUE

Control settings as follows to start:

Power - On: Standby - Operate -- Standby: Transfer Switch-- A.C.: Thermal Balance Controls - (Not important).

Galvanometer Control:

Neither selected, Adjust the "zero" knob until the galvo light beam hairline is over zero (0) on the upper galvo scale. (See terminals and controls, galvo zero in this section.) Apply the A.C. voltage to be measured to the input A.C. terminal. Adjust the input voltage range dials until the input voltage window reads approximately the same as the input voltage. This range should be selected as close to 100% as possible, for best sensitivity and resolution. The range must be selected to within the limits of the balance controls (50% - 130%)in order to achieve a galvo null balance. Finally, the range should be selected so that it is never exceded by more than 150% input as thermo-element burn out will result.

Place the standby-operate switch in operate. Actuate the coarse galvanometer control key. Then, using the thermal balance controls (10% to 1% steps) balance the galvanometer at zero on the upper scale. Turning these controls clockwise moves the light beam to the left and turning counter-clockwise moves the beam to the right. When the galvo is nulled or to within 1 centimeter of null engage the fine galvanometer control key and null the galvanometer using the continuously variable (.1% per revolution) thermal balance control. When nulled, release the Galvo control fine key. Now apply a D.C. voltage approximately equal in magnitude to the A.C. voltage, and therefore approximately equal to the input voltage range setting, to the D.C. terminals. Move the transfer switch to D.C. DO NOT TOUCH the thermal balance controls. With the galvanometer on coarse, adjust the D.C. source in such manner as to achieve a galvanometer null balance. Press galvanometer fine key and adjust the D.C. source to null the galvanometer. Accurately measure the D.C. voltage at the D.C. terminals with a Precision Volt Box, Potentiometer and Certified Standards Cells.

The RMS value of the A.C. voltage is equal to the measured vaiue of the D.C. voltage within the specified accuracy of the Transfer Voltmeter.

2-3 OPERATION - FREQUENCY RESPONSE TESTING:

Control settings as follows to start:

Power - ON; Standby - Operate -- Standby; Transfer switch - A.C.; Thermal Balance Controls - Not important; Galvo control - Neither coarse nor fine selected.

Adjust the A.C. source to the mid band of the frequency response of the instrument being calibrated. Transfer to D.C. and accurately read the amplitude (See par. 2-2). Apply this same A.C. voltage to the device under test as well as the TVI; Note the balance control setting for a null indication and note the indication on the device under test. Adjust the source frequency incrementally and at each increment adjust the source amplitude to achieve null indication on the TVI. Should the indication on the device under test change, it may be assumed it is frequency sensitive. To determine the amplitude deviation, re-adjust the source for the initial indication on the device under test. Re-adjust the TVI balance controls for a null and note the percentage setting on the TVI balance controls. The difference between the original and the present TVI readings, is the percentage change of the frequency response of the device under test. It should be noted that successive transfers to D.C. are not necessary to determine the magnitude of frequency response. For all frequencies under 50 K.C. the TVI will not be influenced outside of the published specifications of the instrument.

2-4 CORRECTION FOR HIGHEST POSSIBLE ACCURACY:

This section is offered to users whose application of this instrument may require accuracy of transfers even beyond the published specifications of the TVI. Since the instrument is basically passive in nature, an analysis of its inherent, limiting errors, however small, is included so that they may, if necessary, be accounted for to achieve results more nearly approaching the absolute. Normal usage will generally require

only that the N.B.S. or the Holt certified accuracy specification be applied.

The factors contributing to the possible errors are these:

$E_1$ = D.C. reversal of the thermocouple

$E_2$ = the frequency response or A.C. - D.C. difference of the transfer circuit.

$E_3$ = the variation in resistance between the A.C. and D.C. paths.

An analysis of each follows:

D.C. reversal error ($E_1$): Due largely to thermocouple construction, the temperature of the junction sometimes depends upon the direction in which the current flows. Alternating current necessarily averages this error. Therefore, unless transfers are made to both polarities of D.C. and averaged, small errors can result.

For greatest accuracy, determine the D.C. reversal error of the instrument (See Section V). This factor is determined at the factory for your convenience and is recorded in the test data accompanying this instrument.

The maximum allowable D.C. reversal error for the TVI is .02% at time of shipment.

A.C. - D.C. Difference error ($E_2$): For frequencys above 50 K.C., the alternating currents through the thermocouple are not necessarily the same as those applied to the front panel terminal. The error due to reactive effects can be determined from data at specific test points supplied by N.B.S. or Holt Instrument Laboratories. It may also be determined from curves supplied upon request from the manufacturer. For frequencies up 50 KC the frequency response of the TVI is essentially flat and

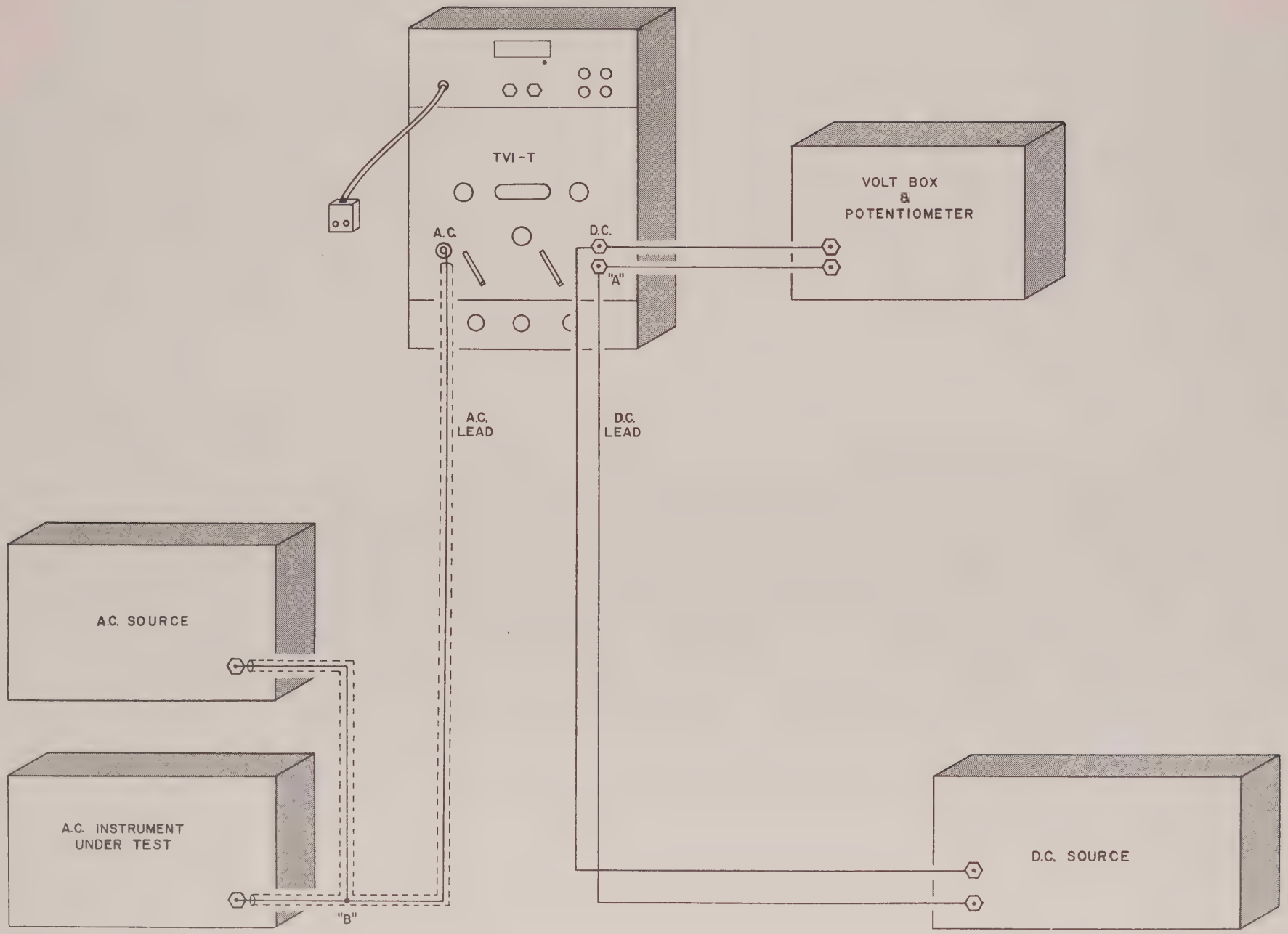

TVI-T
A.C.
D.C.
"A"
VOLT BOX
&
POTENTIOMETER
A.C.
LEAD
D.C.
LEAD
A.C. SOURCE
A.C. INSTRUMENT
UNDER TEST
"B"
D.C. SOURCE

FIG. 2-4-1

the A.C. - D.C. difference is less than the specified .02%. (See technical specifications).

Variation of A.C. and D.C. Path Resistances ($E_3$): This error is probably the most serious the user might encounter since it is dependent upon the lead lengths employed, and not determined or predicted by the factory. The paths within the TVI are essentially identical and the error here is negligible. However, where lead lengths are longer than 18 inches, not necessarily equal for the A.C. and D.C. paths, and of different types or cross-sectional areas, the correction due to this error should be determined and applied.

Refer to figure 2-4-1. Disconnect the A.C. lead from point "B" and connect to point "A". With the transfer switch in the D.C. position, balance controls at exactly 100.00%, input range at 1 volt, apply D.C. voltage to the TVI to balance the galvonometer (approx. 1 volt.). Record the precise magnitude of this D.C. Place the transfer switch in the A.C. position and re-adjust the source for a galvonometer balance and again record the magnitude of the applied D.C. voltage. The difference is the voltage drop across the A.C. lead. The resistance is determined by:

$$R \text{ lead (Ohms)} = \frac{E \text{ (across Lead - volts)}}{.007 \text{ (amperes)}}$$

The correction to be applied to any reading, at any point, using this same lead arrangement, is dependent upon the input resistance of the TVI. This is determined by:

$$R \text{ (input)} = 143 \left[ 1 + K_1(N_1-1) + K_2(10N_2-1) + K_3(100N_3-1) \right]$$

Where:

$K_1 = 1$ when $N_1 = 1$ thru 9

$K_1 = 0$ when $N_1 = 0$

$K_2 = 1$ when $N_2 = 1$ thru 9

$K_2 = 0$ when $N_2 = 0$

$K_3 = 1$ when $N_3 = 1$ thru 9

$K_3 = 0$ when $N_3 = 0$

$N_1$ = integer appearing in the "units" window.

$N_2$ = integer appearing in the "tens" window.

$N_3$ = integer appearing in the "hundreds" window.

The error due to lead length variation ($E_3$) is determined by:

$$E_3 = \frac{R \text{ lead} \times 100}{R \text{ input}} = \quad \%$$

Applying correction:

$$\text{A.C. (volts - absolute)} = \text{D.C. (volts)} - \frac{\text{DC (volts)}}{100} \quad \frac{(E_1 + E_2 - E_3)}{2}$$

Where: The red input terminal is positive and

$E_1$, $E_2$, $E_3$ are in %

D.C. (volts) is the measured D.C. required to null the galvonometer.

Sample Application

Employing a test arrangement similar to Fig. 2-4-1 where the A.C. lead is 6 feet long and the D.C. is measured right at the TVI D.C. input terminals and is 1.00431 volts.

The test point is 1 volt at 200 K.C.

The known quantities are:

$E_1 = -.008\%$ (from factory test data)

$E_2 = -.010\%$ (from calibration curves at 1 volt 200 KC)

Voltage drop in the A.C. lead = .00217 volts.

Therefore:

$$R \text{ lead} = \frac{.00217}{.007} = .31 \text{ ohms}$$

$$R \text{ input} = 143 \left[1 + 1 (1 - 1) + 0 + 0\right] = 143 \text{ Ohms}$$

$$E_3 = \frac{31}{143} = .217\%$$

Now then:

$$\text{A.C. (volts)} = \text{D.C. (volts)} - \frac{\text{D.C. (volts)}}{100} \left(\frac{E_1}{2} + E_2 - E_3\right)$$

$$= 1.00431 - .0100431 (-.004 - .01 - .217)$$

$$= 1.00431 - .0100431 (-.231)$$

$$= 1.00431 + .00232$$

$$\text{A.C.} = 1.00663 \text{ volts (absolute)}$$

D.C. Supply Specifications:

A note at this point concerning the D.C. source employed in the various tests and applications of the TVI. The D.C. source recommended and used by Holt Instrument Laboratories, the Fluke 301 C, most nearly approaches the desired specifications.

Important desired features include; a voltage range from .5 volts to 1200 volts, with continuous resolution; short term stability and ripple not in excess of .01%; direct reading dials (no scale factors); the absence of switching transients which might damage the thermocouples; the ability to ground either side of the output.

When using the recommended D.C. source certain precautions might be taken to more nearly approach these ideal specifications. Place the unit in stand-by before switching output ranges. Also, avoid the use of ranges below 10 volts where ripple is higher and resolution lower. Use higher outputs into a resistive attenuator to achieve lower voltages.

## 3-1 GENERAL:

The transfer voltmeter consists of six major circuits, each defined by its purpose and not necessarily their physical proximity. Refer to Figure 3-3-1, the TVI Block Diagram. This Figure simplifies the overall instrument so that the function of each major circuit and its relationship to the others can be observed.

The instrument basically makes use of the transfer principle in which a D.C. voltage is substituted for the A.C. voltage to be measured. The D.C. voltage is adjusted to give the same output E.M.F. of the thermo-element that was obtained with the A.C. voltage applied, and is measured with a potentiometer, with sources of suitable waveform, average-reading and crest-reading instruments can be calibrated. In all applications, the applied frequency need not be closely determined or held because of the flat frequency response of the instrument.

A specific theoretical explanation of each circuit comprising the TVI will be made in this section. First, a brief introduction to them.

A. THE RANGE SELECTOR AND TRANSFER DEVICE located in the center section is comprised of a coaxial transfer switch and three drums, each with ten coaxial resistors selected from front panel controls.

B. THE THERMOCOUPLE MODULE contains the transfer thermo-element circuit as well as the temperature compensating thermo-element. This module is directly connected to the galvonometer circuit but plugged into and physically located within the TVI-T chassis.

C. THE GALVONOMETER CIRCUIT consists of two low thermal, precious metal keys in a portable control box, a low impedance resistive network on the galvonometer terminal board, and a high resolution, double light beam galvonometer.

D. A D.C. POWER SUPPLY provides plate voltages to the operational amplifier and a very stable direct current to drive the secondary or opposing thermo-elements.

E. A THERMAL BALANCE UNIT Consists of two decade switches having steps of 10% and 1% and a ten turn potentiometer, the smallest division of which is .001%.

F. A CHOPPER STABILIZED D.C. AMPLIFIER which senses and sums the three balance control inputs and maintains a predictable constant current through the secondary or opposing thermo-element.

3-2 RANGE SELECTOR - TRANSFER DEVICE

The voltage multiplier resistance of the TVI is made up of three decades of resistors mounted coaxially in individual shield tubes. In operation, these tubes are connected in series with the input lead and are terminated with the thermo-element. These coaxially mounted multiplier resistors are mounted on the circumference of three drums, each drum being controlled by a front panel knob. Rotation of the drums aligns the desired resistor for a 143 Ohm per volt multiplier string in one volt increments from one volt to 999 volts. The advantage of having one volt incremental setting permits the use of the instrument at its maximum resolution and sensitivity at 999 separate cardinal points over the operating range. When the operate switch is engaged, the drums are moved along their shafts to connect the selected resistors with precious metal, low resistance plugs.

Since the range resistors form a series multiplier network and not a voltage divider circuit, the D.C. voltage being transferred to must be of equal magnitude to the A.C. voltage under test. Therefore, the absolute resistance value of the multipliers is unimportant. Only the frequency response and short term stability enter into the transfer accuracy.

The frequency response varies directly with the shunt capacity along the multiplier resistors. Mr. F.L. Hermach, of the National Bureau of Standards*, has proven that: "For cylindrical construction.....

$$L = .012\ \ell M \qquad \text{Eq. 3-2-1}$$

and:

$$C = 0.61\ \ell/M \qquad \text{Eq. 3-2-2}$$

where:

$$M = \log_{10}(g/h) \qquad \text{Eq. 3-2-3}$$

$\ell$ = length of the cylinder in inches

g = cylinder diameter

h = resistor diameter

L = Series inductance (Microhenries)

C = Shunt capacity (picofarads)

Therefore, a cylindrical configuration may be chosen which minimizes shunt capacity and extends the frequency range of the resistor.

* Paper entitled "Thermal voltage Converters for Accurate Measurements to 30 Megacycles per Second" F.L. Hermach and E.S. Williams

In addition, the entire length of the coaxial line from input terminals to the thermocouple is only 34 inches long. The short overall length keeps error due to standing waves very small. At 50 kilocycles this length of line represents less than.015% of one wavelength.

Throughout the TVI-T use is made of precious metal sliding junction switch contacts. The sole contact affecting measurement accuracy is that of the transfer switch. For this reason a sliding, coaxial switch is employed, the resistance of which is extremely low and extremely repeatable.

3-3 THERMOCOUPLE MODULE:

This unit incorporates the latest techniques in the application of thermo-elements to measurements. Within each module are two sections. The inner compartment houses a series resistor and the transfer thermo-element. The outer compartment houses the compensating or opposing thermo-element and the output circuits of both thermo-elements. A four conductor, shielded cable connects the thermo-couple module to the TVI-G and the galvonometer circuit. This circuit has no plug contacts so that stray thermal E.M.F's are minimized.

The transfer thermo-element plus the series resistor total 143 Ohms. With 1 volt applied to the module input, the full rated current of 7 ma. will flow. For operation at higher voltages, additional series resistance is added in the range selector (See para. 3-2). Mounting the compensating and transfer thermo-elements within the same module serves the purpose of temperature compensation. Changes in ambient affect both elements. The couple outputs are connected in series bucking thereby

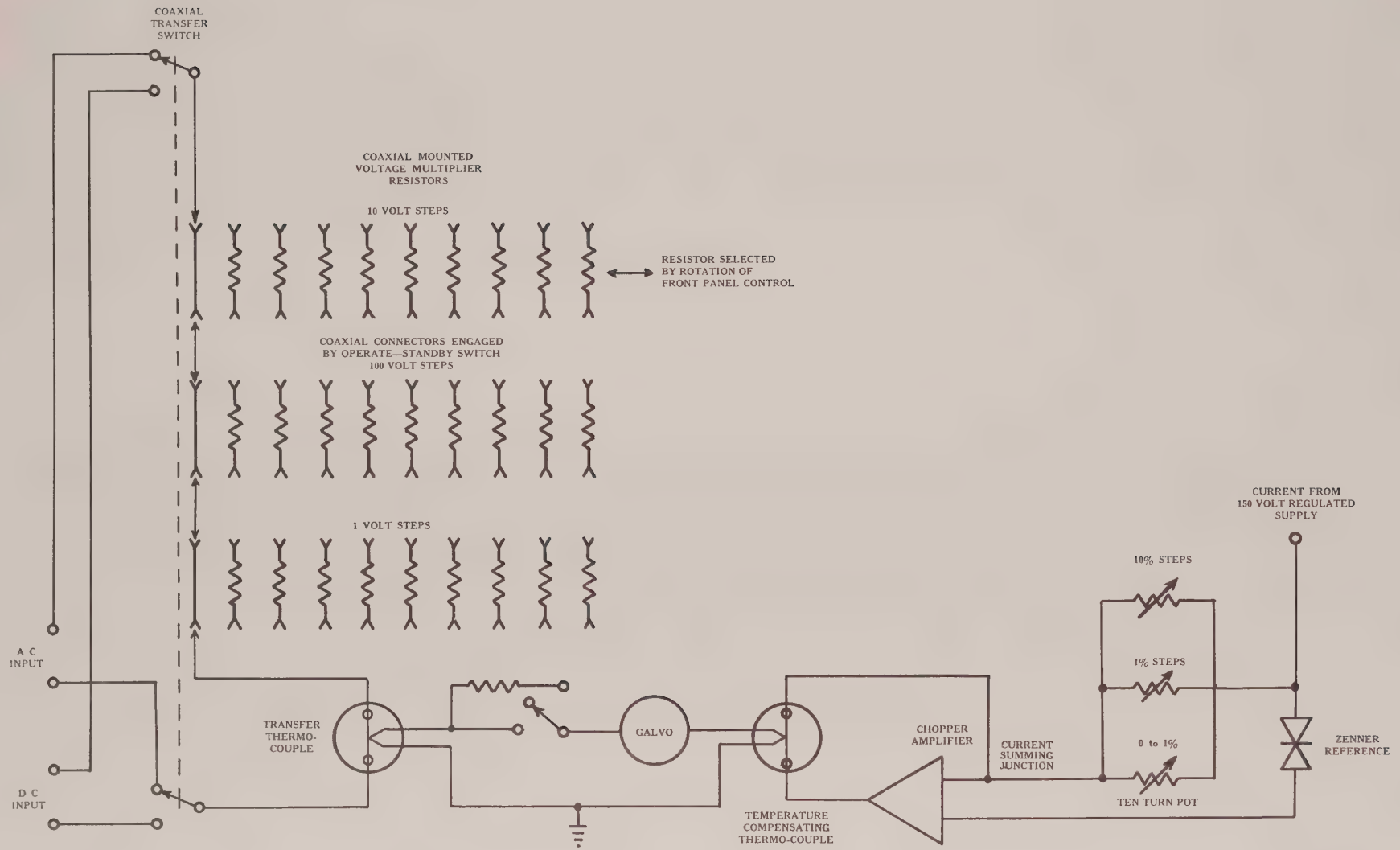

COAXIAL TRANSFER SWITCH
COAXIAL MOUNTED VOLTAGE MULTIPLIER RESISTORS
10 VOLT STEPS
RESISTOR SELECTED BY ROTATION OF FRONT PANEL CONTROL
COAXIAL CONNECTORS ENGAGED BY OPERATE—STANDBY SWITCH
100 VOLT STEPS
1 VOLT STEPS
A C INPUT
D C INPUT
TRANSFER THERMO-COUPLE
GALVO
TEMPERATURE COMPENSATING THERMO-COUPLE
CHOPPER AMPLIFIER
CURRENT SUMMING JUNCTION
CURRENT FROM 150 VOLT REGULATED SUPPLY
10% STEPS
1% STEPS
0 to 1%
TEN TURN POT
ZENNER REFERENCE

FIG. 3-3-1

cancelling ambient temperature drift.

The temperature compensating thermo-element also permits linear calibration of the balance controls. Refer to the block diagram, Fig. 3-3-1. It can be shown that for a linear change in A.C. input, the output of the transfer thermo-couple will change according to a square law function. The compensating thermo-element output is also a square law function of its heater current, so that its input is a linear function at the input to the transfer thermo-element. Thus, the square law relationship usually associated with thermocouples is cancelled out. The temperature balance controls may therefore be calibrated in terms of percent change in A.C. input voltage.

Each thermo-element is adjusted so that with rated current through the heaters an EMF of 8 millivolts, open circuit, is produced at the couple. The couples are the glass bead insulated types, providing a thermal path but not an electrical connection from heater to couple. In fact, electrical breakdown of the bead disturbs the operation. (See bead leakage - Section V).

## 3-4 THE GALVONOMETER CIRCUIT:

The electrical balance between the outputs of the two thermo-elements is measured by the galvonometer circuit. The galvonometer is a standard, L.& N.,2430A double light beam galvonometer. The galvanometer circuit is a continuous, soldered, all copper circuit except for the "fine" and "coarse" push buttons. To minimize thermal EMF's, the push buttons utilized are L. & N., low thermal, low resistance, precious metal galvo keys. The keys are located in a portable box for operator convenience. The "coarse" key provides 1/10 the sensitivity of the "fine"

key. With neither position engaged the external critical damping resistance of the movement is placed across the galvonometer movement. The sensitivity of the galvonometer is .004% per millimeter or better.

The entire galvo circuit is a guarded circuit. All shields and cases are connected together isolating the circuit from ground. All components, including the galvonometer movement, are within the guard circuit.

3-5 THE D.C. POWER SUPPLY:

This circuit provides a dual D.C. supply but is otherwise standard in every respect. The positive supply employs a vacuum tube, full wave rectifier and capacitive filter. The output is a gas tube regulated at +255 volts. The +255 volts supplies two plates and bias to the D.C. amplifier. It also is further reduced and filtered to drive the cathode follower stage of the D.C. amplifier.

The negative supply is solid state and full wave with a capacitive filter. Its output is gas tube regulated at -105 volts. The initial zener diode regulates the output at -30 volts. The second zener diode controls the output at about -6.2 volts. The regulated output at this point is used to drive the compensating thermocouple, as well as to provide bias to the V-205 tube. Incorporated in the power supply is the A.C. filament supply providing A.C. power to all the filaments and the chopper drive. The total power load at the line is less than 50 watts.

## 3-6 THERMAL BALANCE UNIT:

The balance unit controls the amount of current fed to the summing junction of the D.C. amplifier. It will be explained later that this current is the same as the current through the compensating thermo-element. The balance control consists of three parallel variable resistances ($R_a$, $R_b$, $R_c$, Fig. 3-7.1) in series with the D.C. supply. The finest control is a 10 turn, continously variable potentiometer ($R_a$) that varies current to 1%. The smallest division on the dial is .001%. The 1% steps from 0% to 9% are metal film resistors ($R_b$) on a 10 position switch. The 10% steps from 50% to 120% are wire wound precision resistors ($R_c$) with a deposited carbon resistive shunt ($R_c$) to ground which maintains a somewhat more constant load on the zener power supply.

## 3-7 CHOPPER STABILIZED D.C. AMPLIFIER:

This is a high gain operational amplifier with a low impedance output circuit. The heater of the compensating thermo-element is connected in the current feed back circuit around the amplifier. See Fig. 3-7.1. The feed back current is equal to the input current since only a very small current can flow in the high impedance chopper, grid circuit. The D.C. amplifier open loop gain is high enough to keep the summing junction at a very low voltage ($\pm$ 10 MV.). The input resistors are connected from the summing junction to the zener voltage ($E_2$). $I_1$ is therefore $E_2/R_a + E_2/R_b + E_2/R_c$. Therefore the current through the feed back circuit (and the thermo-element) must equal the sum of the currents through the thermal balance unit controls.

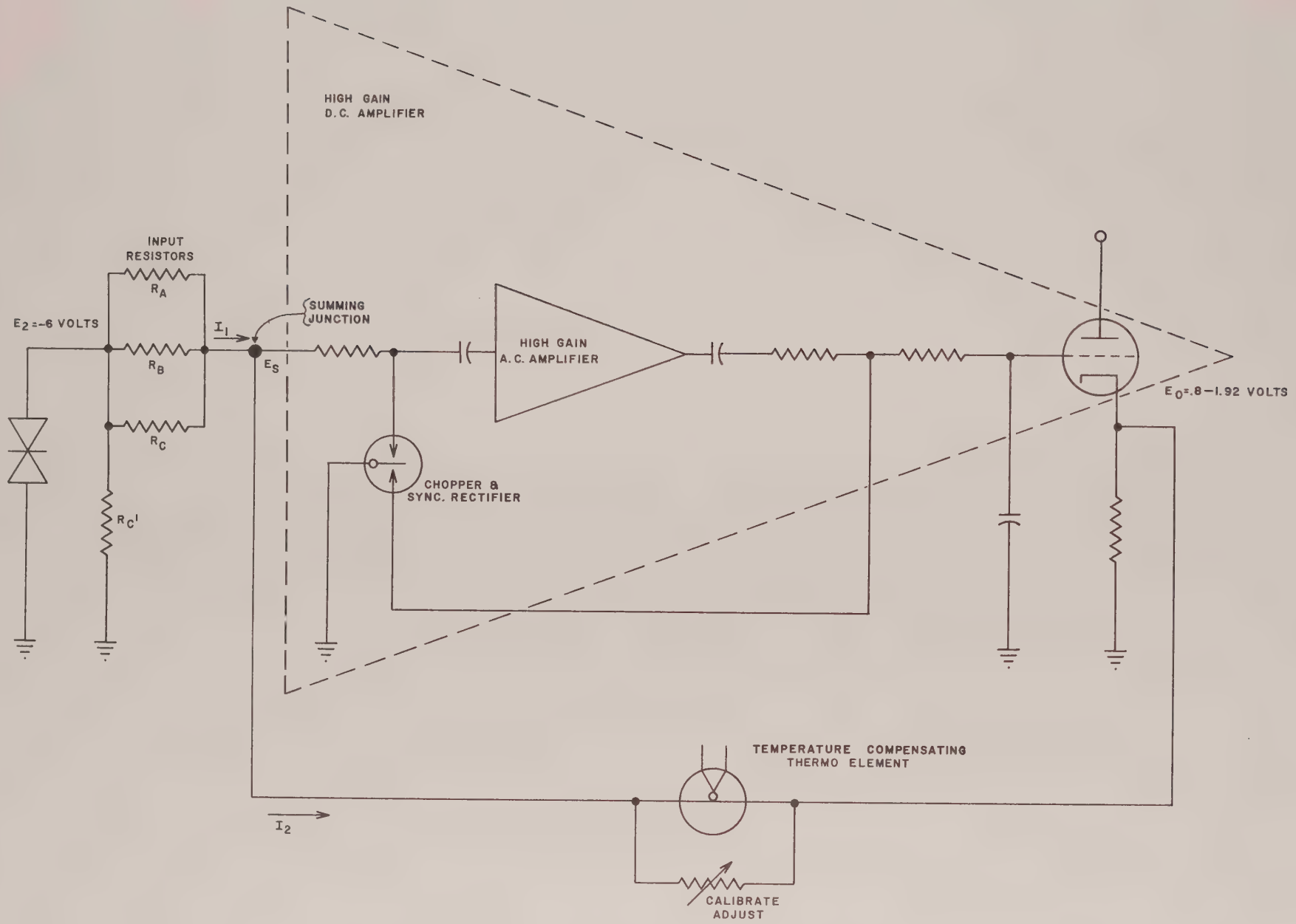

HIGH GAIN
D.C. AMPLIFIER
INPUT
RESISTORS
$R_A$
$R_B$
$R_C$
$R_C'$
$E_2$ = -6 VOLTS
$I_1$
SUMMING
JUNCTION
$E_S$
HIGH GAIN
A.C. AMPLIFIER
CHOPPER &
SYNC. RECTIFIER
$E_0$ = .8 - 1.92 VOLTS
TEMPERATURE COMPENSATING
THERMO ELEMENT
$I_2$
CALIBRATE
ADJUST

Fig. 3-7-1

## 4-1 GENERAL:

The following procedure is designed to lead the serviceman, in logical progression, through the various stages of tests on the TVI. Its purpose is to assure the proper functioning of the unit prior to calibration. If each step is completed in order, all phases of operation will have been tested. The field servicemen can further benefit by referring to the factory check list and data sheet accompanying this manual. This data is collected using the following procedure and can be used as a guide in any subsequent maintenance.

## 4-2 RECOMMENDED TEST EQUIPMENT:

The following list of recommended test equipment is included as a guide. This is the equipment used throughout the maintenance procedure at the factory. To exactly duplicate factory data, it may be necessary to utilize identical or very similar equipment. Data collected with substitute instrumentation must be analyzed in light of their individual specifications.

Wheatstone Bridge.....Otto Wolff 944

Stable A.C. Voltage Source.....Holt AVS-321

Potentiometer.....Leeds Northrup $K_2$ or $K_3$
Otto Wolff KF-4 or KF-5

Standard Cells.....Eppley Model 100

Vacuum Tube Voltmeter.....11 meg ohm input
3% full scale accuracy

Oscilloscope.....Tektronix Type 531

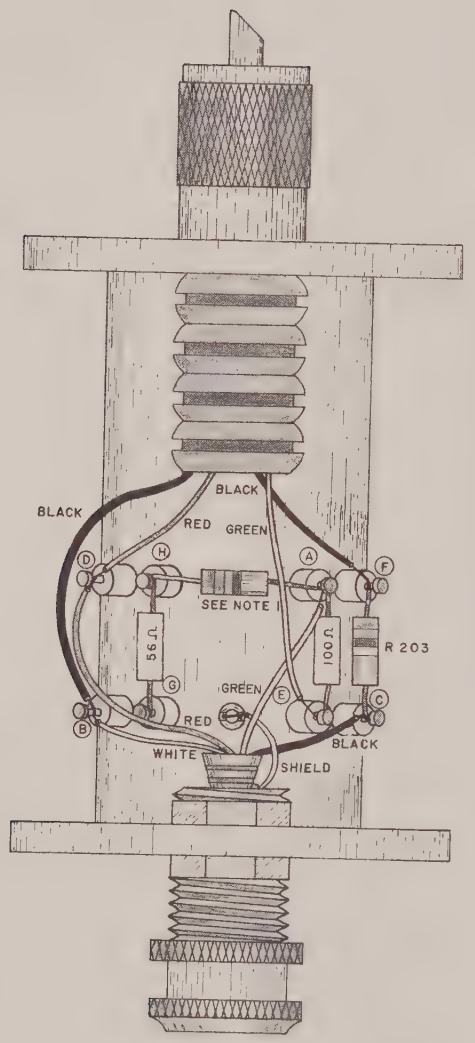
4-3 PROCEDURE:

4-3.1 THERMOCOUPLE MODULE CHECK:

Accurately bridge the input resistance of the primary or transfer thermo-element by first removing the module from the TVI-T and connecting the bridge to the input coaxial connector. Extreme caution must be used in that the applied current necessary to determine the input resistance should never be in excess of 7 milliamperes. The input resistance (including R-100-internal) should be 142.85 ohms ± 1%. An open circuit would indicate an open thermo-element. Once assured the thermo-element input resistance is normal, apply 1 volt (± 1%) A.C. or D.C. to the input of the module. Using a potentiometer, measure the thermocouple output E.M.F. This potential will be developed across the 100Ω resistor in the output network of the thermo-element. (A & E Fig 4-1). This resistor is physically located within the module and is accessible once the outer shield tube is removed. Caution, do not break the seal on the end of the cannister. The output potential, with exactly 1 volt applied should be 8 M.V. ± 2%. (Note: The Galvo keys must be open). A low output would indicate a faulty thermo-element.

The temperature compensating thermo-element, is mounted in rubber to prevent shock damage. Its heater and series resistor (R-203) should be bridged. The proper total resistance of the heater circuit should be 800 ohms ± 5%. Turn on the TVI-G with the balance control connected and set at 100%. The voltage across the compensating thermo-element heater should be 1.6 volts ± 5% measured from point (c) Fig. 4-1 to chassis ground. The output of the compensating thermocouple should be 8 M.V. ± 2%, measured with a

# TOP VIEW SKETCH—THERMOCOUPLE MODULE (SHIELD REMOVED)




NOTE 1:

FACTORY SELECTED FOR 8 MV. OUTPUT. SEE OPERATING & SERVICING MANUAL.

FIG. 4-1

potentiometer at points D & E Fig. 4-1. Disconnect all power from the unit before proceeding with the test sequence.

Notice! If after making the above test, the transfer thermo-element is judged faulty, remove the entire cannister by unsoldering the cable where it enters the cannister and contact Holt Instrument Laboratories or its authorized representative for a replacement module. Do not open or attempt to open the inner module.

4-3.2 GUARD CIRCUIT:

This test is for purposes of determining the continuity of the guard circuit, as well as assuring its isolation from other circuitry. Using the lowest range of an ohmeter be sure a continous circuit exists between the thermocouple module case, test point 205 on the operational amplifier assembly (See Fig. 6-4), the guard terminal on the TVI-G front panel and the case of the galvonometer movement within the TVI-G. With the standby-operate switch in standby, the guard circuit should be isolated from chassis ground and signal common. With the standby-operate switch in operate and the transfer switch in A.C., the guard circuit is connected to chassis ground at the A.C. terminal on the front panel of the TVI-T. Switching the transfer switch to D.C., should again isolate the guard circuit from chassis ground.

4-3.3 CHASSIS GROUND CIRCUIT:

In the measurement of A.C. voltages, especially in the R.F. region, the presence of good grounding is vital to the accuracy of the measurement. The sensitivity of the temperature sensing circuit is so high that stray R.F. is capable of presenting serious problems. Since the three units comprising the

TVI are completely metal shielded, R.F. interference is at a minimum. However, best results are obtained when the three sub-units are buss connected together and returned to earth. Terminals are provided at the rear of each sub-unit for this purpose.

The ground circuit should be continous from each of the three chassis; signal common on the power supply and operational amplifier circuits to earth ground. This can be checked by using the lowest range on an ohmmeter.

4-3.4 CONTROLS - FREEDOM, RANGE, ORIENTATION:

A thorough check of the freedom, range and orientation of all controls at this point in the maintenance procedure can prevent back-tracking later on, to make corrections. Operate each of the following controls over its entire range:

Galvonometer zero - located immediately below the TVI-G bezel. Capable of eight full revolutions, mechanically stopped at each end.

Coarse and fine galvonometer sensitivity keys, both located on the galvo control box are spring loaded to the up position. Each is capable of being locked down by depressing and turning 1/4 turn clockwise.

TVI-B - 10% decade, farthest left on the TVI-B front panel, has eight positions. It is mechanically stopped at each extremity.

TVI-B - 1% decade, center control on the TVI-B front panel, has 10 positions. It too is mechanically stopped at each extremity.

TVI-B - .1% decade, located on the right side of the TVI-B front panel, is a ten turn potentiometer. This control is limited mechanically to only 10 complete turns.

TVI-T hundreds, tens and units decades are indexed for 10 positions but are not mechanically stopped, all dials should increase with clockwise rotation on the controls.

TVI-T transfer and standby-operate switches are two position. Each position mechanically stopped approximately 150° apart.

4-3.5 VISUAL CHECK - COMPONENTS AND ASSEMBLIES:

Prior to applying power to the TVI, a brief visual inspection is in order. Inspect the power supply and operational amplifier assemblies to insure all components are properly installed. Check for missing wires, poor solder joints and loose connections. If all seems well, connect the TVI-B to the TVI-G (PL-300 to J-300). Plug the line cord into a 115 volt 60 cps source and turn the unit on. Observe all circuitry for obvious overheating, if all seems well proceed to the next check.

4-3.6 GALVONOMETER - OPTICAL ALIGNMENT:

All units shipped from the factory have had the galvonometer optics aligned prior to shipping. Generally, therefore, the hairline and light beam reticle should appear bright and sharp on the galvonometer scale. If, however, it does not, first attempt to mechanically zero the light beam. If the galvo still fails to respond, refer to the LEEDS & NORTHRUP manual, accompanying this instrument, for the detailed alignment procedure.

4-3.7 TVI-G POWER SUPPLY CHECK:

Two things should be noted as the various test points are checked in thissprocedure. First, read and record the amplitude of each voltage, using the VTVM. Second, with an oscilloscope,

| TEST POINT | VOLTAGE | RIPPLE PEAK TO PEAK |
|---|---|---|
| Case, C-201 | -260 | 8 volts |
| Pin 2, 4, 7, V-203 | -105 | 7 MV. |
| Pin 4, Z-200 | -30 | 5 MV. |
| Pin 2, Z-200 | -6.5 | 2 MV. |
| Pin 1, 5, V-201 | +255 | 10 MV. |
| C-208 | +120 | 2 MV. |

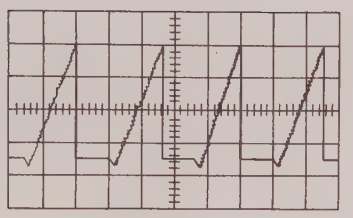
TABLE 4-2

| REF. NO. | TYPE | PIN NUMBERS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| V-204 | 12AX7 | +85 | -.3 | .75 | FIL. | FIL. | +170 | 0 | 1.9 | FIL. |
| V-205 | 6C4 | +112 | N.C. | FIL. | FIL. | N.C. | -3.5 | 1.6 | | |

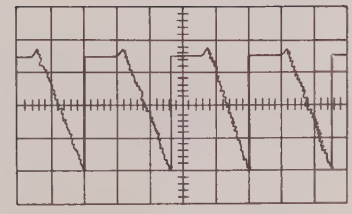
TABLE 4-3

| REF. NO. | TYPE | SECTION | VOLTAGE GAIN |
|---|---|---|---|
| V-204 | 12AX7 | 1st Half | 60 |
| V-204 | 12AX7 | 2nd Half | 70 |
| V-205 | 6C4 | | .70 |

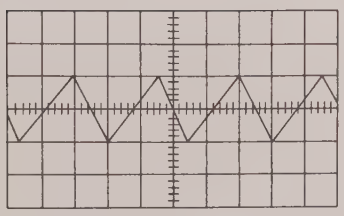
TABLE 4-4



PIN 7, V-204
350 MV. PEAK TO PEAK
FREQUENCY = 60 CPS
TV1-B CONTROLS AT 100.00%



PIN 7, V-204
400 MV. PEAK TO PEAK
FREQUENCY = 60 CPS
TV1-B CONTROLS AT 50.00%



PIN 6, V-205
1.5 VOLTS PEAK TO PEAK
FREQUENCY = 60 CPS
TV1-B CONTROLS AT 100%

measure the peak to peak value of power supply ripple. The D.C. voltage-power supply chart in table 4-2, lists the major test points and the normal D.C. voltages, polaritys and ripple amplitudes. Any deviations from the noted values should be checked in detail. Refer to drawing number 1184 in the rear of this manual for the circuit schematic. Some assistance may also be obtained by referring to the factory test data for this particular instrument, wherein is recorded the data actually measured prior to delivery from the factory.

ZENER STABILITY:

To assure maximum stability, the two zener diodes employed in the TVI are mounted within an oven, and run for several weeks under normal circuit conditions. Daily checks on the output potential determines the diodes stability characteristic, as well as its mean output potential. Units displaying long term drift, instability, or unexplanable shifts in output are rejected.

Furthermore, the oven housing the two diodes is checked to assure proper oven cycling.

The output of the high voltage diode and the low voltage diode may be read at pins 6 and 8 respectively of Z-200 with respect to signal common. Refer to table 4-2.

4-3.8 OPERATIONAL AMPLIFIER CHECK:

As an initial indication of the operational amplifier's general condition, read the voltage at each pin of V-204 and V-205. Compare each reading with the table of normal voltages in table 4-3. Favorable comparisons should be made in all instances is the TVI-B controls are set to 100.00% and either the dummy load

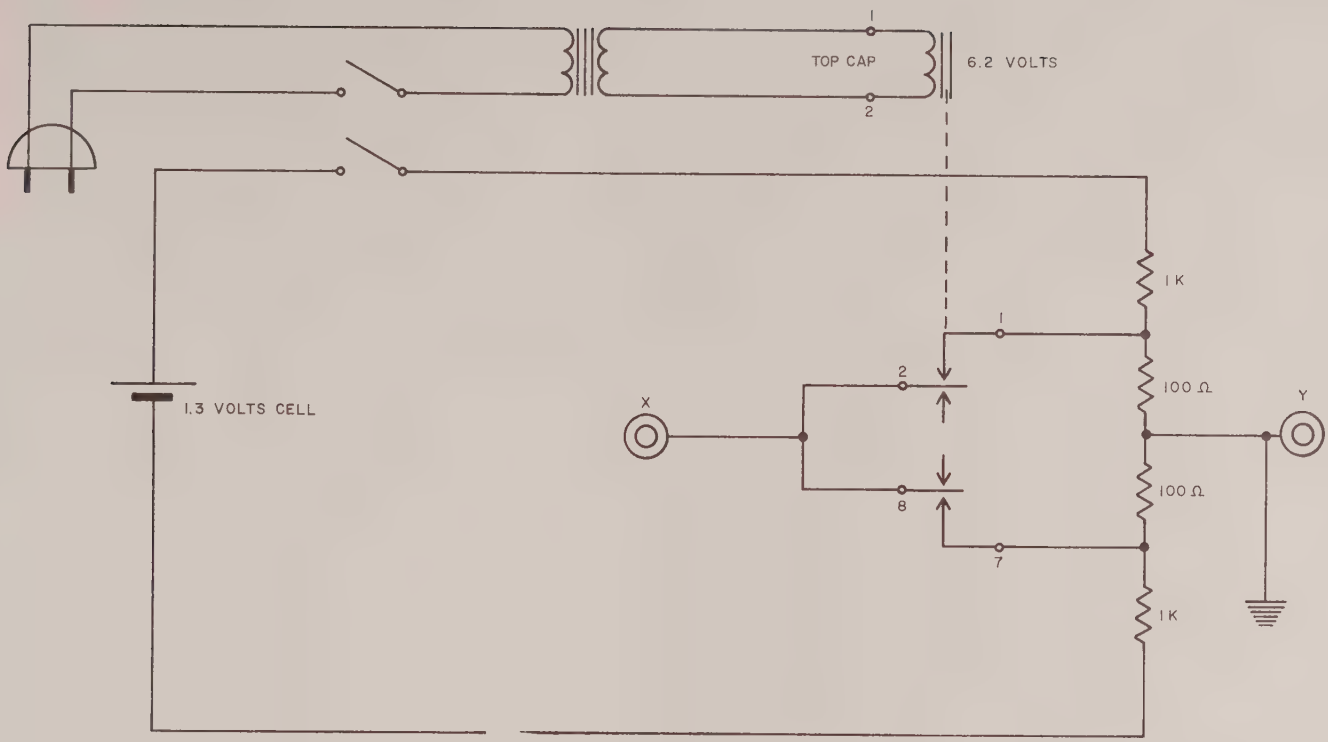
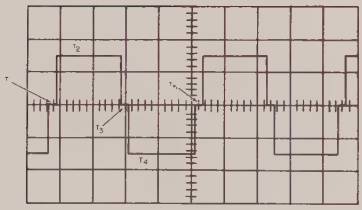



Fig. 4-6

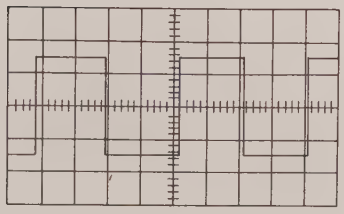


* CORRECT WAVEFORM

$T_1=T_3=T_5$ = 0.8 MS $\pm$ .1MS

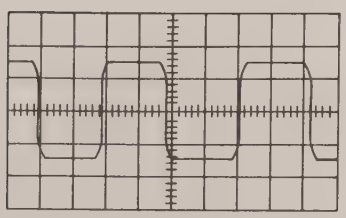
$T_2=T_4$ = 7.5 MS. $\pm$ .2MS

RATE = 60 CPS



* INCORRECT WAVEFORM

INDICATES CONTACTS NOT SHORTING NOR OPENING.



* INCORRECT WAVEFORM

INDICATES CONTACTS OPENING EACH HALF CYCLE

*All waveforms recorded at terminals "X" and "Y". of the circuit in Fig. 4-6.

Fig. 4-7

or the thermocouple installed as explained in paragraph 4-3.9.

Table 4-5 lists the important average waveforms normally observed at the noted test points throughout the amplifier. Factory testing has indicated that close observance of these waveforms constitute the best test of the chopper circuit. The waveforms do very considerably as the TVI-B controls are changed over their range. For clarity, those drawn in Table 4-4 are for specific TVI-B settings as noted.

Since the linearity capabilities of the operational amplifier is inherently dependant on the forward gain of the circuit, table 4-4 lists the voltage gains of each stage. The listed gains are minimums.

CHOPPER TESTING:

The instrument chopper (G-200) employed in the operational amplifier, under goes complete testing and adjusting to insure proper operation. The procedure is carried out in a test jig expressly designed for this purpose. A schematic of that test circuit is included in Figure 4-6. The important considerations being, first; adjust for equal closure times on each contact: Second, optimizing the time that each reed mutually engages its contact. Fig. 4-7 shows three waveshapes, two of which are the result of common maladjustment. These waveforms and/or those in Figure 4-4 best indicate amplifier malfunction due to the chopper device.

4-3.9 LINEARITY OF THE BALANCE CONTROLS:

Set the TVI-B controls to 100.00%, and install a dummy resistive load of 800 ohms in place of the temperature compensating thermo-element. The load can best be installed in the thermo-

couple module. Refer to Figure 4-1. Remove the black wire from point B and connect the lead from point B to point C.

Connect a potentiometer between pin 7 of V-205 and circuit common. Adjust R-222 and R-226 for exactly 1.6000 volts at this point. R-222 and R-226 are the coarse and fine thermo-element balance controls located on the rear of the TVI-G. Now, readjust the TVI-B controls to 50.00% and read the new voltage at pin 7 V-205. This voltage should be linear with respect to the TVI-B controls based on 1.6000 volts being 100%. The tolerance at any point is .1%. Check the linearity over the entire range (50% to 120%). Refer to the factory test data for the readings recorded during the factory check out procedure.

## 5-1 GENERAL:

To precisely calibrate the TVI, it is necessary to have at least a minimum of stable, variable, A.C. sources operative within the specified frequency range of the TVI and a Standard Transfer Device, N.B.S. tested or certified to accuracies as good as, but preferably better than, the Model TVI. Any additional required instrumentation used to regulate, indicate or monitor is dependent on the techniques involved. The following recommended test equipment and calibration procedure are those used by Holt Instrument Laboratories. It must be assumed that identical or comparable equipment and techniques are required to exactly duplicate our recorded results. The techniques described and the equipment recommended are the result of several years' work in the precision instrumentation and standards fields. Only because our results have compared favorably with those recorded on N.B.S. test reports for the same instruments, may we assume the validity of the following calibration procedure.

It is further assumed that the tests described in the preceding section have been accomplished and the TVI is performing satisfactorily at this point. All subsequent tests and adjustments directly affect the accuracy of the TVI or its controls.

## 5-2 RECOMMENDED TEST EQUIPMENT:

Vacuum tube voltmeter.....11 meg ohm input resistance
3% full scale accuracy

Wheatstone Bridge.....Otto Wolff 944

D.C. Source.....Fluke - Model 301C

Volt box.....Leeds & Northrup 7592 or
Wolff - 540

Potentiometer.....Leeds Northrup K2 or K3 or
Otto Wolff KF-4 or KF-5

Standards Cells.....Eppley - Model 100

A.C. Source, 35-20 000 cycles.....Holt Instrument Lab. AVS-321
with extended range transformers

R.F. Source, 85KC - 40 MC.....B & J Model 20
B-J Div. of Borg-Santa Ana

Type C Thermal Elements.....Holt Instrument Laboratories
Specification 90102

Galvanometer & Balancing Unit.....Holt Instrument Laboratories
Specification 90103

Tuned Circuit & Transfer Unit.....Holt Instrument Laboratories
Specification 90104

R.F. Meter.....Hewlett Packard Model 410B

5-3 CALIBRATION PROCEDURE:

5-3.1 TESTING THERMOCOUPLE BEAD LEAKAGE:

Place the standby-operate switch in the standby position and remove the link from between the guard and T.C. common terminals on the TVI-G front panel. Connect an ohmmeter between these terminals. The total resistance between these points is the total bead leakage of the A.C. or transfer thermo-element. This resistance must be in excess of 100 meg ohms.

Place the unit in operate with chassis grounds on the rear of the instrument sub assemblies connected. Again read the resistance between the guard and D.C. common terminals. The resistance now indicates the bead leakage of both the A.C. or transfer thermo-element (TC-100) and the Temperature Compensating thermo-element (TC-200) and should be greater than 100 meg ohms. Should

the resistance in either case drop below the specified minimum, the thermo-element or thermo-elements will possess high leakage characteristics directly affecting the accuracy of transfer. The thermocouple module should be replaced.

5-3.2 BRIDGING MULTIPLIER RESISTORS:

Place the unit in standby, rotate the input range controls to 0 volts and place in operate. Remove the TVI-T top cover. Disconnect the thermocouple module and remove it. Short the center conductor of the U.H.F. receptacle in the TVI-T to the shield. Connect the precision resistance bridge between the red and black D.C. input terminals. Place the transfer switch in the D.C. position and read the total resistance. After each reading go to standby, select the next range, and return the standby-operate switch to operate and read. Check the 30 cardinal points referred to in Table 5-I for the maximum and minimum values. This test verifies not only true resistances in each unit, but checks the continuity of the entire resistance circuit and return path. A check on the resistive difference between the A.C. terminals and D.C. terminals is accomplished by reconnecting the bridge to the A.C. terminals and placing the transfer switch in A.C. and reading the new resistance. A comparison of these two readings on the same range should reveal little or no difference (Less than 30 milli-ohms). Correction for these small residual differences are discussed in section 2-4.

5-3.3 LEAKAGE TEST:

Important: Remove the shorting link from J-200 on the front panel of the TVI-G and leave the TVI open circuited.

With the TVI open circuited (no thermocouple module - no shorting link), select any input range and place the unit in

| POSITION | MIN. R. (OHMS) | MAX. R. (OHMS) |
|---|---|---|
| 0 | - | - |
| 1 | - | - |
| 2 | 142.15 | 142.85 |
| 3 | 284.29 | 285.71 |
| 4 | 426.93 | 429.07 |
| 5 | 568.58 | 571.42 |
| 6 | 712.25 | 715.58 |
| 7 | 854.86 | 859.14 |
| 8 | 997.50 | 1002.5 |
| 9 | 1139.2 | 1144.2 |
| 10 | 1281.8 | 1288.2 |
| 20 | 2713.2 | 2726.8 |
| 30 | 4129.7 | 4150.3 |
| 40 | 5556.1 | 5583.9 |
| 50 | 6982.5 | 7017.5 |
| 60 | 8418.9 | 8461.1 |
| 70 | 9835.4 | 9884.6 |
| 80 | 11252 | 11308 |
| 90 | 12660 | 12732 |
| 100 | 14005 | 14295 |
| 200 | 28116 | 28684 |
| 300 | 42174 | 43026 |
| 400 | 56430 | 57570 |
| 500 | 70488 | 71912 |
| 600 | 84645 | 86355 |
| 700 | 99802 | 100800 |
| 800 | 112860 | 115140 |
| 900 | 126920 | 129460 |

TABLE 5-1

operate. Move the transfer switch to A.C. and connect the test circuit consisting of a VTVM and a 90 volt D.C. source to the A.C. input terminal. See figure 5-2 for circuit details. This circuit should be closely adhered to. Any deviation would permit measurement of leakage resistance in the test apparatus and would not truly indicate that of the TVI.

The leakage resistance is determined by:

$$R_{leakage} = \frac{(E_1 - E_2)\, Rm}{E_2}$$

Further testing should be done at the D.C. terminals and at other input ranges to assure proper operation at different points.

5-3.4 GALVO RESOLUTION AND POLARITY:

Set the TVI-T input voltage controls to 100 volts, transfer switch to D.C., standby-operate switch to operate. Set the TVI-B balance controls to exactly 100.00%. Apply exactly 100.00 volts D.C. to the D.C. input terminals of the TVI. Adjust the coarse and fine D.C. thermocouple adjustments on the rear of the TVI-G (R-222 and R-226) as necessary to achieve a galvo null balance. Reset the input D.C. voltage to 100.10 volts (0.10% increase). Note the number of millimeters the galvo reticle deflects. (Minimum allowable is 26 mm). The resolution may be expressed by:

$$\frac{0.10\%}{\text{No. of mm.}} = _____\ \% \ / \ \text{mm.}$$

Example (minimum allowable):

$$\frac{0.10\%}{26} = .00385\ \% \ / \ \text{mm.}$$

It should also be noted that for input voltages higher than that set on the TVI, galvonometer deflection should be to the right. For lower input voltages the galvonometer should deflect to the left.

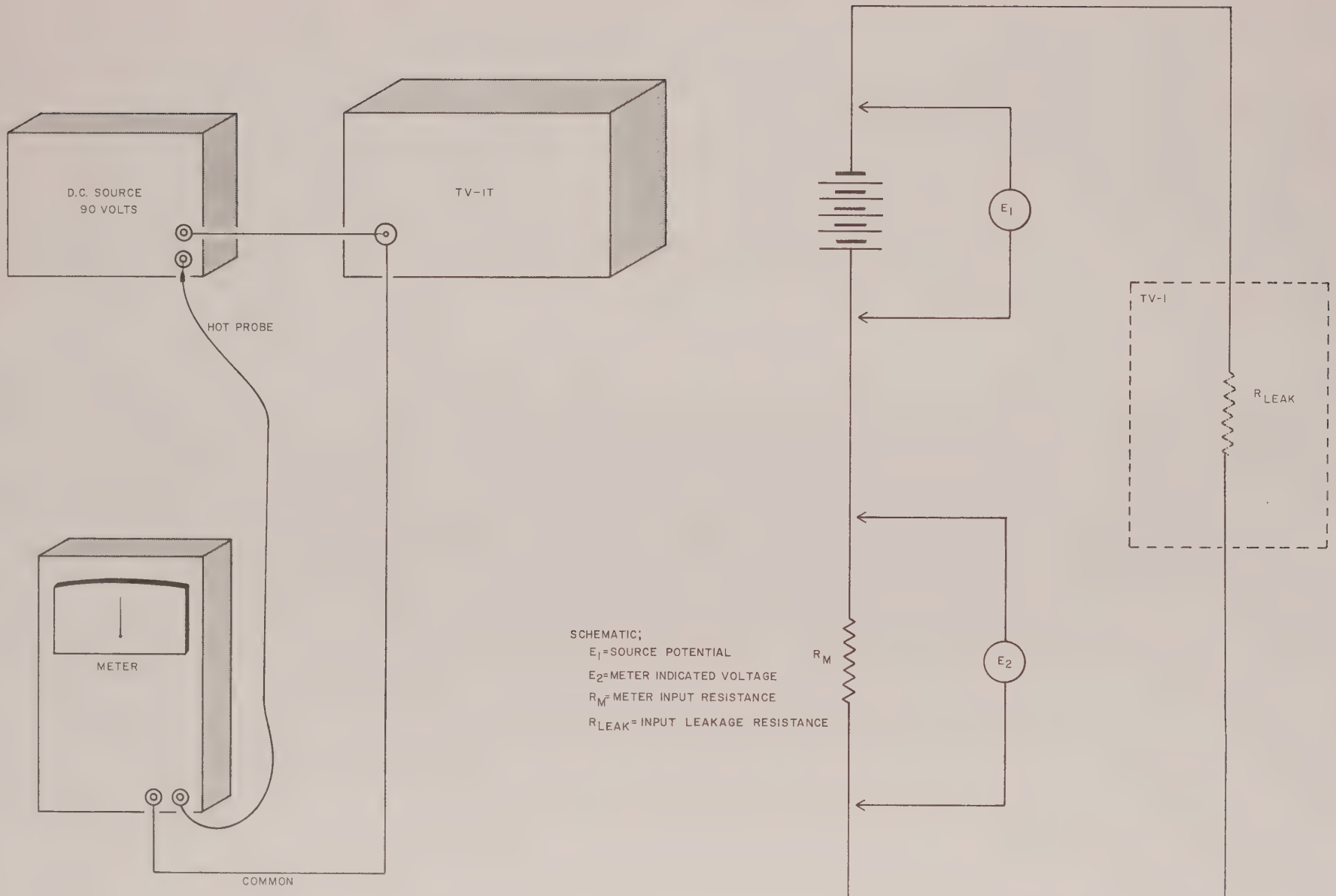

D.C. SOURCE
90 VOLTS
TV-IT
HOT PROBE
METER
COMMON
SCHEMATIC;
$E_1$=SOURCE POTENTIAL
$E_2$=METER INDICATED VOLTAGE
$R_M$=METER INPUT RESISTANCE
$R_{LEAK}$=INPUT LEAKAGE RESISTANCE
$E_1$
TV-1
$R_{LEAK}$
$R_M$
$E_2$

Fig. 5-2

5-3.5 RESOLUTION BETWEEN BALANCE CONTROL EXTREMITIES:

With balance controls set at exactly 100.00%, range controls at 100 volts, adjust the applied D.C. for an exact null balance. Then readjust the TVI-B balance controls for 99.999%. The galvo should settle at a point several millimeters above zero, indicating an overlap of the control ranges. This overlap is a necessity. Should this test reveal a gap between the control settings, decrease the value of R-326. This resistor reduction is best accomplished by shunting it with a much larger resistor. The amount of overlap is small, but nonetheless, necessary.

5-3.6 TVI-T RANGE CHECK - ALL RANGES:

To insure all ranges are operative, select each cardinal input voltage range. Apply the same voltage as the input voltage scale reading. Adjust the balance controls for a null indication. All cardinal points should null at 100% $\pm$2% with 100.00% voltage applied. For example, 10 volts applied to the 10 volt range should balance somewhere between 98.000% and 102.00%.

5-3.7 D.C. REVERSAL:

Set the input voltage controls for 100 volts. Set balance controls for exactly 100.00%. Apply enough D.C. (positive polarity) to exactly balance the galvonometer. Read the D.C. voltage at the TVI input terminals with a volt box and precision potentiometer.

Place the Fluke 301C in standby and reverse the polarity of the applied D.C. voltage to the TVI and adjust the D.C. source for null balance. Be certain to keep the chassis of the Fluke 301C connected to the black terminal of the TVI. Return the 301C to operate and again read the D.C. voltage at the terminals precisely.

Repeat the above procedure several times, and determine the average plus to minus deviation. Convert this voltage difference to percentage of the total applied voltage. This reversal error should not exceed .015%. If the negative D.C. causes galvonometer deflection to the right, the sign of the D.C. reversal error should be positive. If negative D.C. causes deflection to the left, the error is negative. This correction should be applied as in Section 2-4.

Example:

E+ = Voltage for red term positive

E- = Voltage for red term negative

$$E_1 = \frac{(E+)-(E-)}{\left(\frac{E+ + E-}{2}\right)} \times 100 = \text{D.C. reversal in } \%$$

5-3.8 RESISTOR CHARACTERISTICS - THERMAL EFFECTS:

The largest contributing factor to stability of the TVI is the temperature co-efficient of the multiplier resistors. Generally the resistors wattage rating is large enough so that the temperature rise is small and consequently the resistive change due to temperature rise is very small. However, several resistors are operated at points where slight heating occurs. The effect of this temperature rise is a short term change in resistance and a short term drift in the galvonometer. Several of the more serious points are checked in the following manner;

Apply a D.C. voltage equal to the TVI-T dial setting. Wait 5 minutes and balance the galvonometer. Then remove the input voltage for 3 minutes and then reconnect it. Immediately close the galvo course key and record the number of millimeters and direction of movement each 15 second interval until the galvo returns to null. It will be noted that all ranges settle out in

a time constant of 90 seconds. Maximum transient should not exceed 1%, about 30mm on the course scale and should be within 30mm on the fine scale in 3 minutes.

5-3.9 BALANCE CONTROL LINEARITY:

It is assumed in the following procedure, that the preceding D.C. reversal test has been accomplished.

Set the TVI-T input voltage controls for 100 volts and apply exactly 120.00 volts D.C. to the input terminals. Adjust the TVI-B balance controls for a null balance. Record the balance control setting. Increase the D.C. applied voltage to 120.12 volts. Record the number of millimeters the galvo reticle is displayed from null.

Reduce the input voltage to 110.00 volts. Adjust the TVI-B balance controls for a null balance. Record the balance control setting. Increase the D.C. applied voltage to 110.11 volts. Record the number of millimeters the galvo reticle is displaced from null.

Repeat this procedure at 90.00 volts, 80.00 volts, 70.00 volts and 60.00 volts. The resulting data will indicate the magnitude of the non-linearity in the thermo-elements; the non-linearity of the balance controls (previously checked); and the difference in resolution depending on what percentage setting is used.

5-4 A.C. - D.C. DIFFERENCE PROCEDURE:

The frequency response of the TVI, more commonly referred to as the A.C.-D.C. difference, is probably the most difficult determination made. Since the measurements are of small quantities, extreme stability of the source and sensitivity of the sensing circuit is required. Holt Instrument Laboratories employs

a number of techniques each peculiar to a portion of the frequency spectrum that the TVI covers.

5-4.1 20 TO 20,000 CYCLES:

In this, the audio region, considerable individual testing against certified standards has been accomplished with extremely repeatable results. The conclusion may be made that the A.C.-D.C. difference is practically non-existant at these frequencies. Nevertheless all units are tested in this region to insure repeatability and the validity of our conclusion. The test technique is as follows:

Using both a variable A.C. and a variable D.C. source, three TVI's are connected in parallel to a transfer switch. Two of these units are new instruments, the third an N.B.S. certified unit. The inputs to the switch are A.C. and D.C. variable up to 1000 volts. First, an A.C. voltage is applied to all instruments on the same range and all galvonometers are nulled. Then in succession, a positive D.C., a negative D.C. and the A.C. are applied. With each voltage, the one TVI is used as a "standard" and the source adjusted to achieve a null balance. The other instruments under test are merely read in terms of millimeters away from null.

Assuming that all voltages are applied at approximately equal time intervals, the two A.C. readings determine the drifts of all instruments. The two D.C. readings are averaged which eliminates error due to D.C. reversal. The averaged D.C. readings are determined and compared to the average of the two A.C. readings. The difference is the A.C.-D.C. difference in terms of millimeters to one side or the other of null. Knowing the resolution of each instrument (See "galvonometer resolution" this section), the per-

centage A.C.-D.C. difference is quickly computed. At least 4 readings should be taken at each voltage and frequency and the results averaged to reduce random errors. For most accurate results, lead length error must be considered. (See Section II - "Operation for Greatest Accuracy").

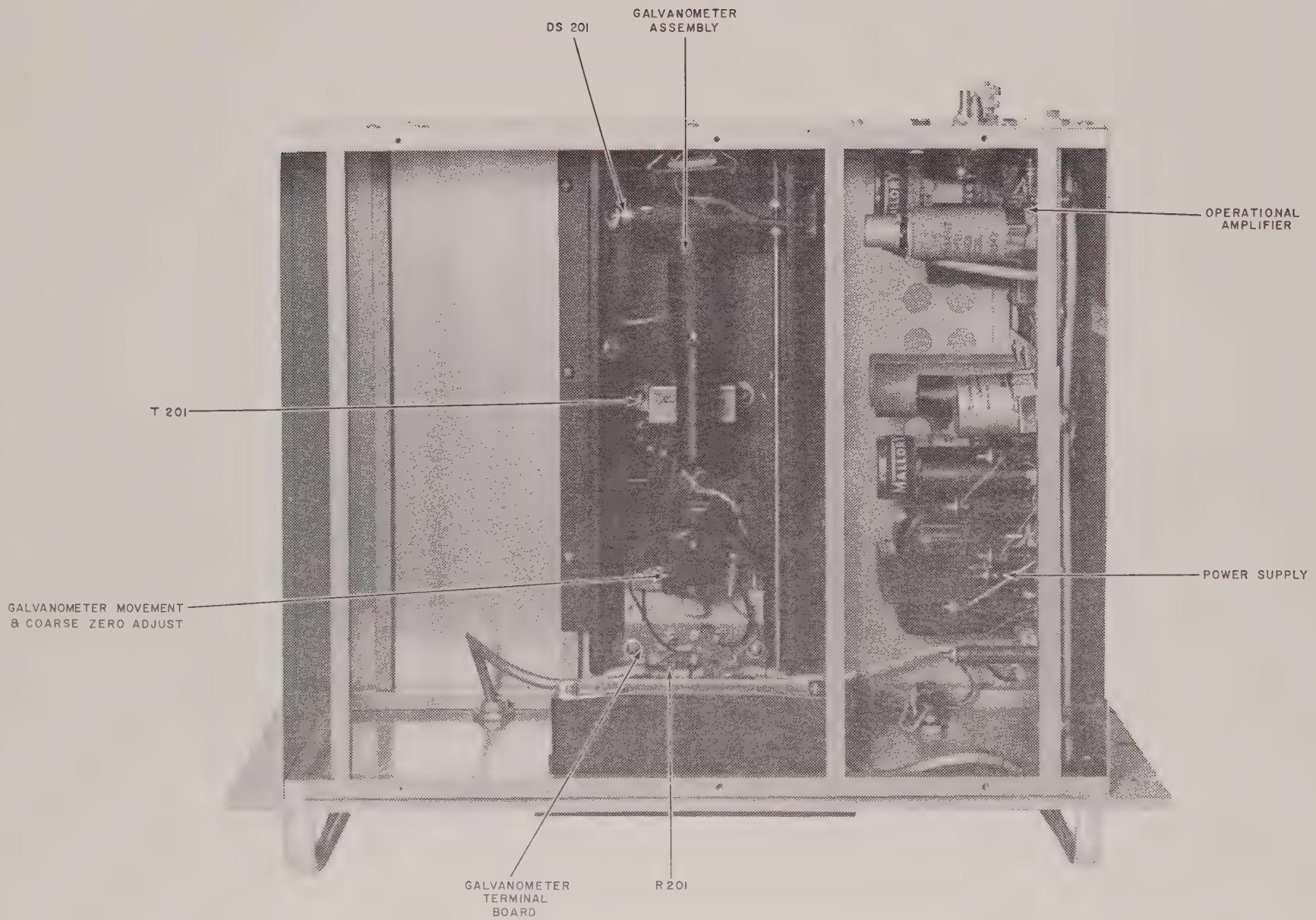
5-4.2 D.C. DIFFERENCE - 85 K.C.:

Computation, verified by research, proves that the points most influenced by higher frequencies are those points where the highest resistor in each decade is engaged. Therefore, if the points considered most serious are tested and found to be within the required specifications, the others are assumed to be much better.

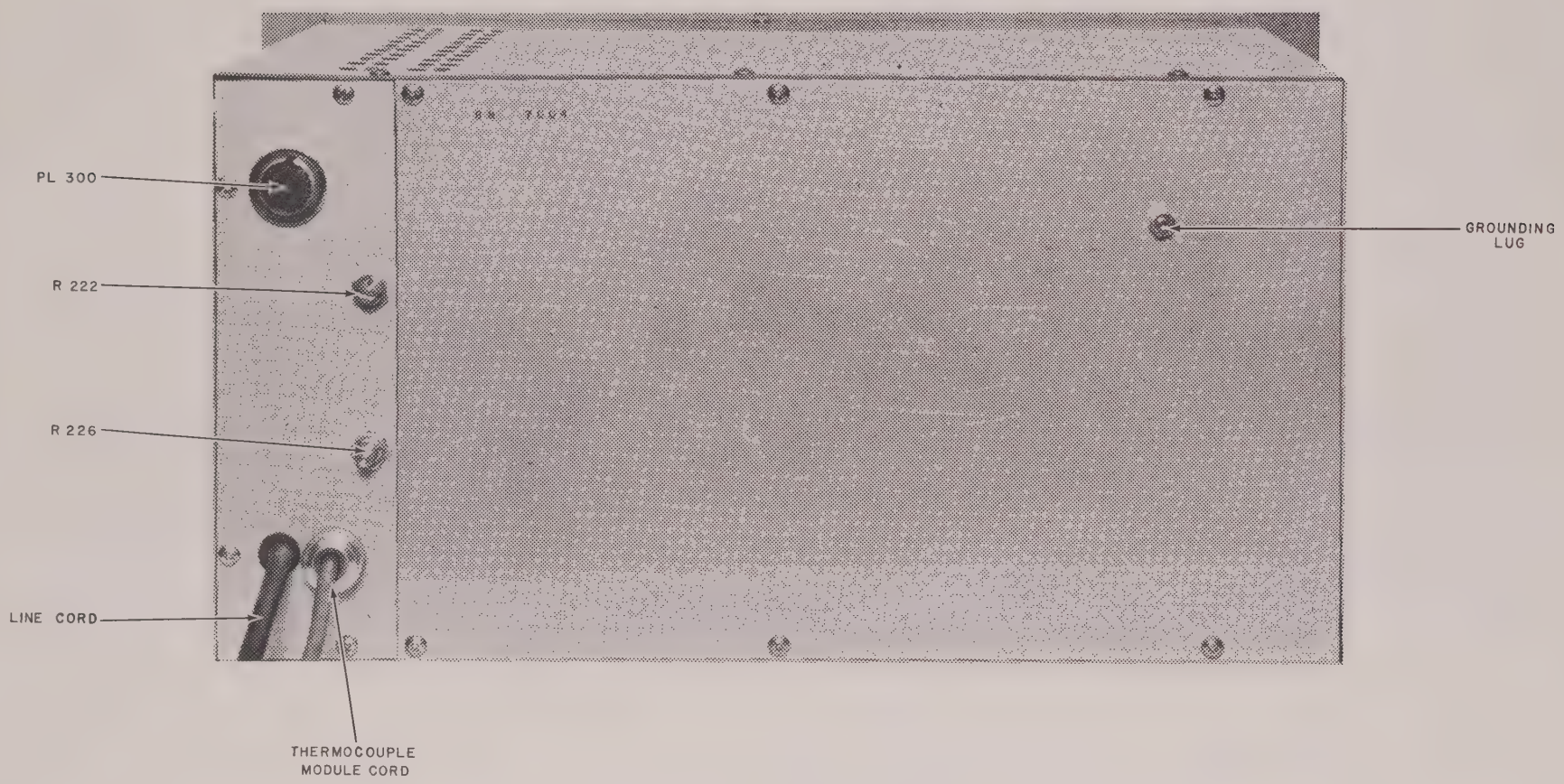
At these frequencies, the TVI is checked individually against type C thermal elements. These elements, developed by the National Bureau of Standards, are capable of high accuracies up to 30 megacycles. A complete set permits measurements from below one volt to 200 volts. The procedure is somewhat similar to that used at lower frequencies. A stable, variable source of RF is used. Its output is applied to a transfer switch with the output of another A.C. source at a frequency well down in the audio region. The low frequency source is used because it has previously been determined that the A.C.-D.C. difference in the low audio region is very small. Also, an A.C. source eliminates the need to correct for D.C. reversal error. The R.F. is set first using a coarse R.F. meter, then applied simultaneously to the type C and the TVI under test. Both are nulled. Then the low frequency A.C. is applied and varied until a null is indicated on the standard instrument (Type C). The millimeter deviation,

if any, on the TVI is noted, and then R.F. is re-applied and adjusted for a standard null balance. Again, the TVI deviation from null is noted. Assuming the three tests are accomplished over approximately equal time periods, the average of two R.F. readings will eliminate drift in either instrument. This average R.F. is compared to the low frequency A.C. deflection.. Knowing resolution, the percent R.F. to low frequency A.C. difference can be computed. This, for all practical purposes, is the A.C.-D.C. difference at the R.F. frequency. The points checked as a matter of record on all TVI's are the 19,99,199 and 299 volt ranges at 85 KC. Specific customer requirements often necessitate reading other voltage ranges and frequencies. Furthermore, units going to N.B.S. for certification are checked at each of the required N.B.S. test points. This same technique is employed in the determination of calibration curves to 5 megacycles.

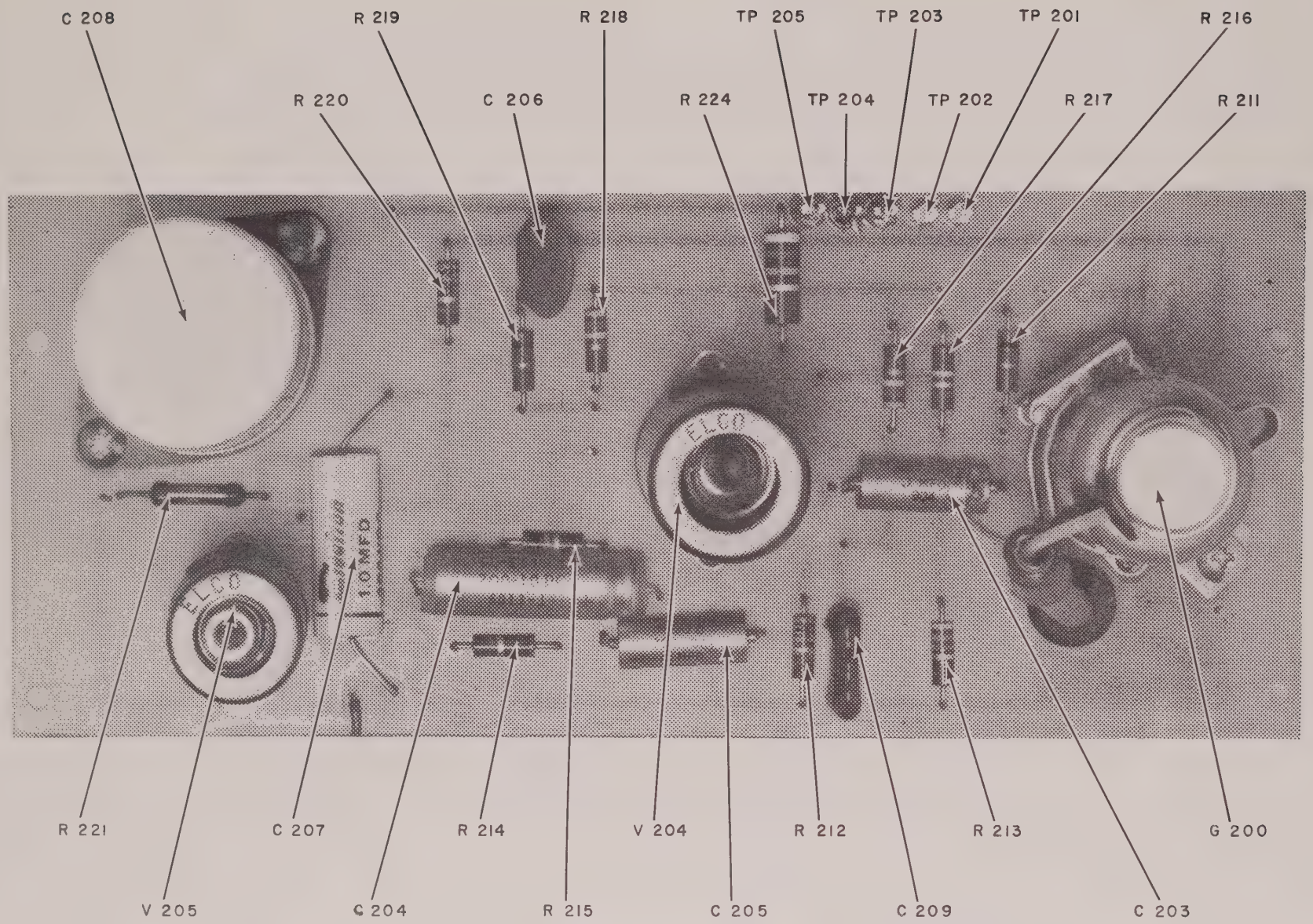
Fronr View TVI-G
Fig. 1



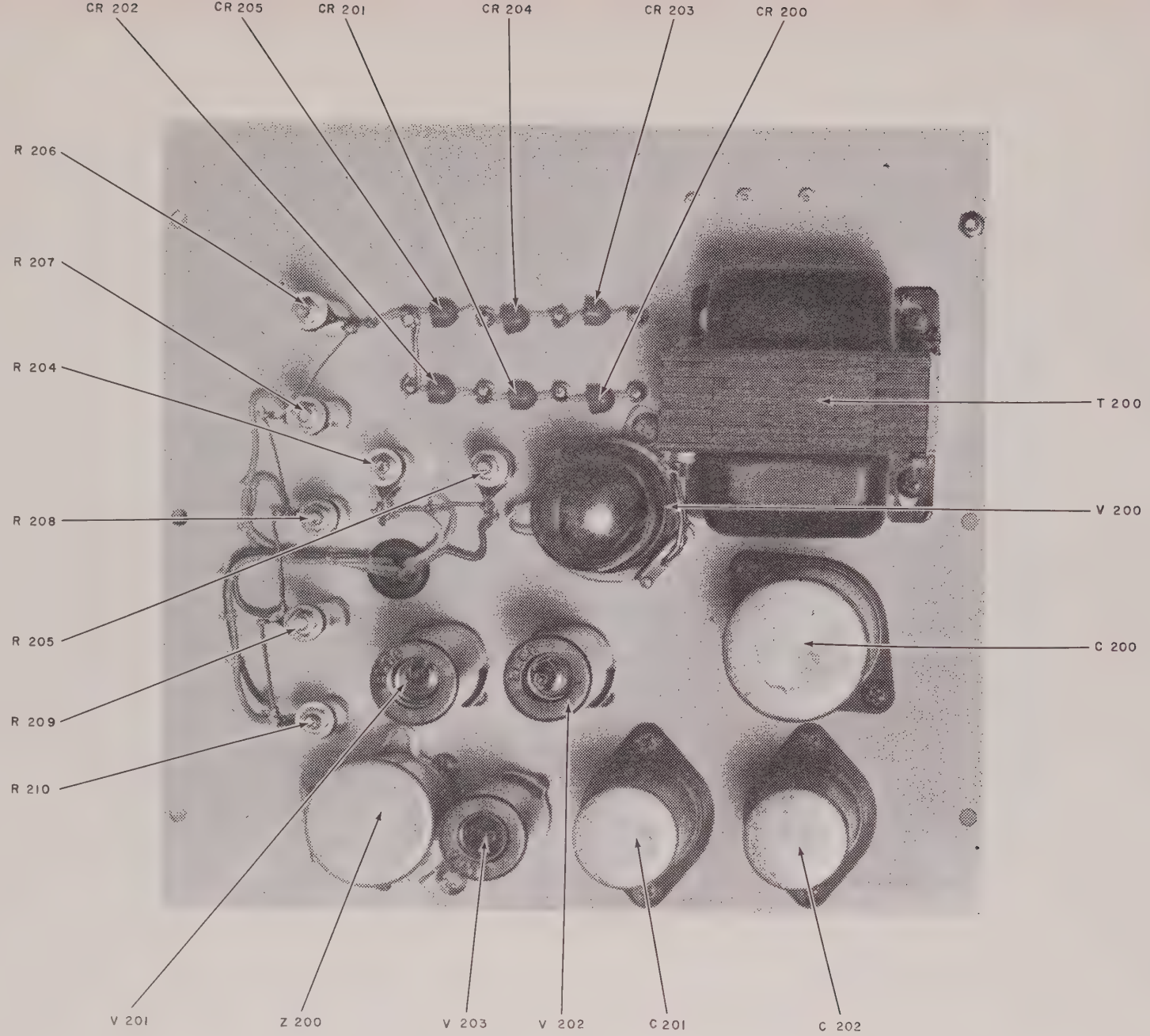

Top View TVI-G
Fig.-2



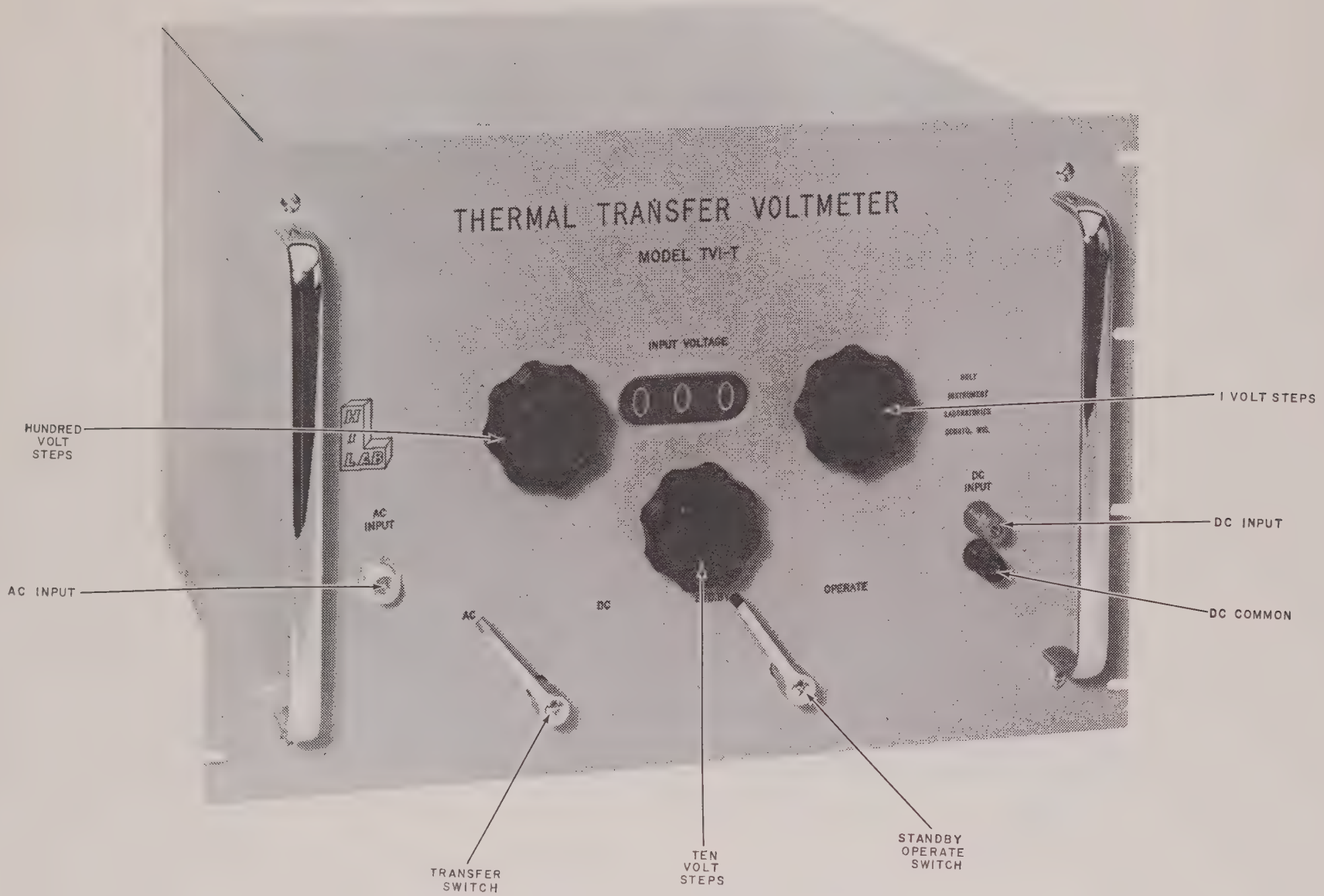

Rear View TVI-G
Fig.-3



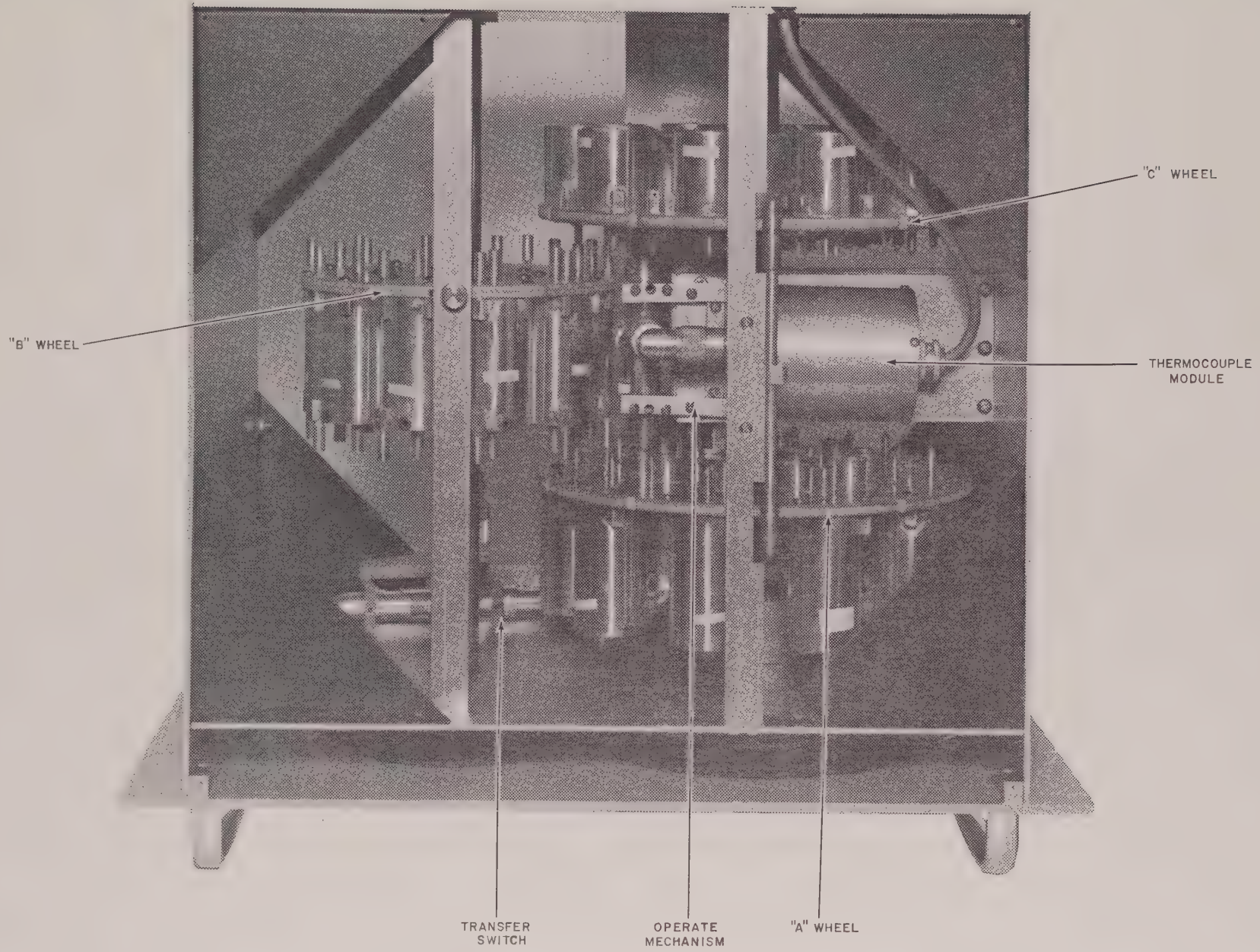

Operational Amplifier TVI-G



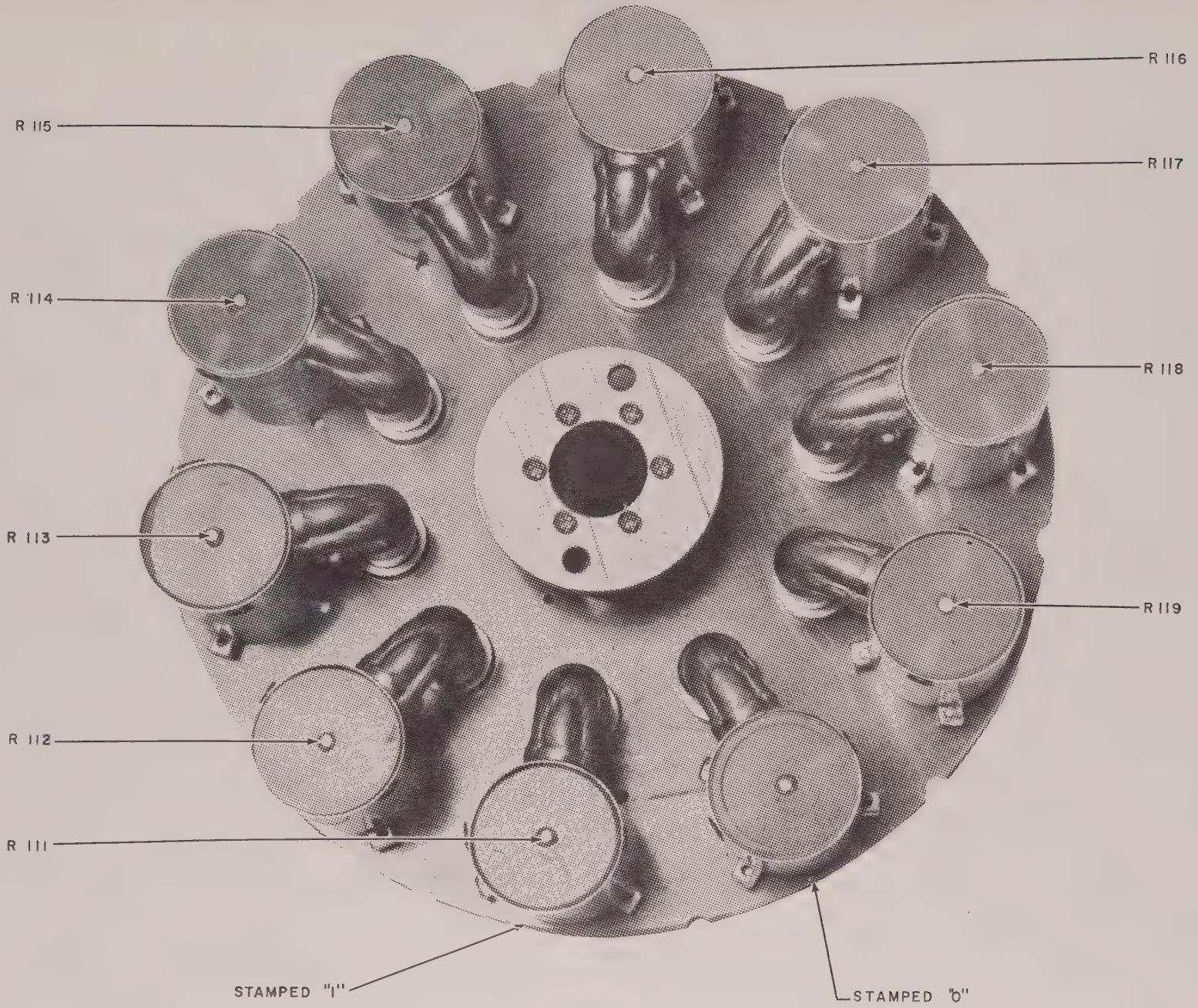

Power Supply TVI-G
Fig.-5



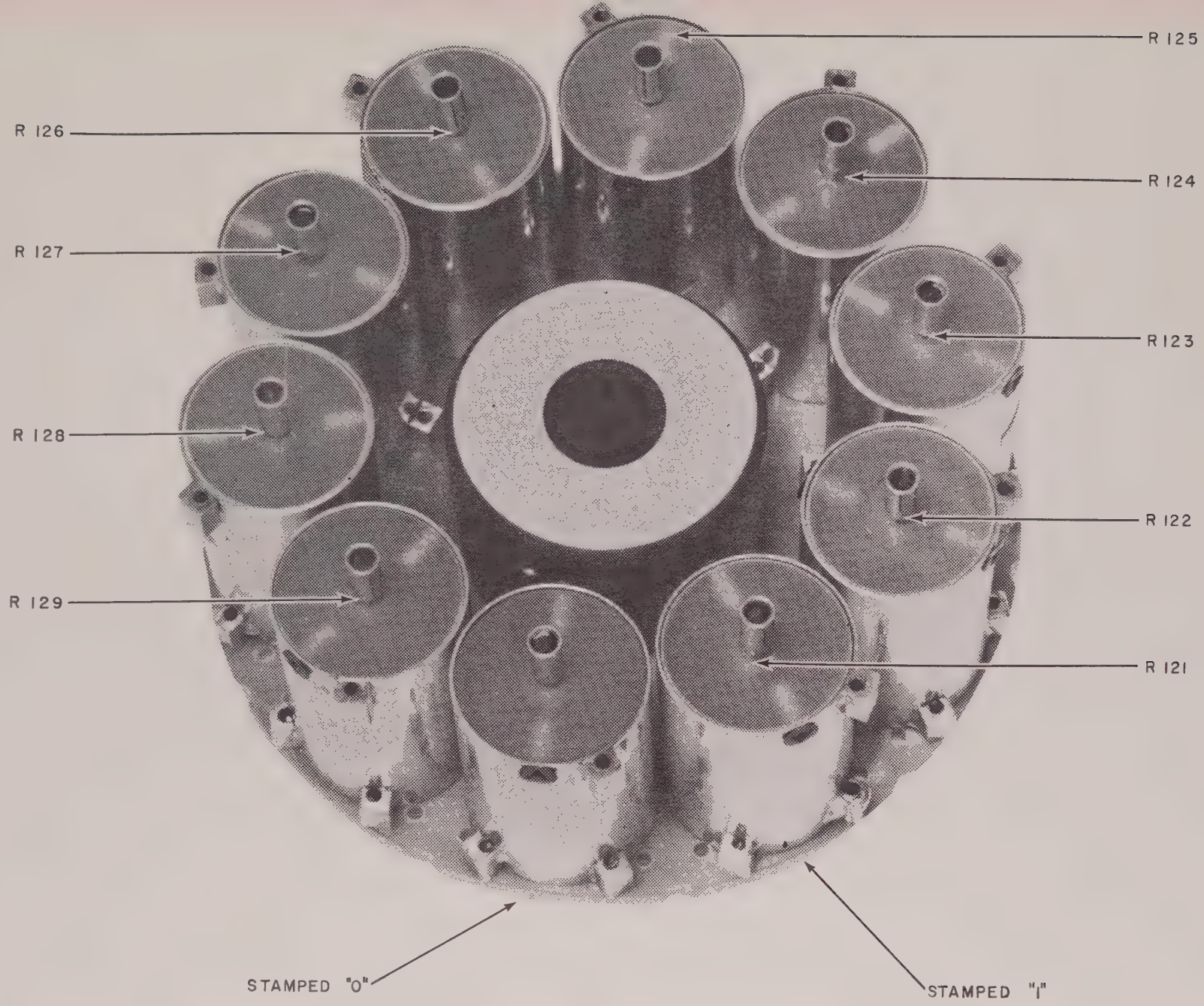

Front View TVI-T
Fig.-6



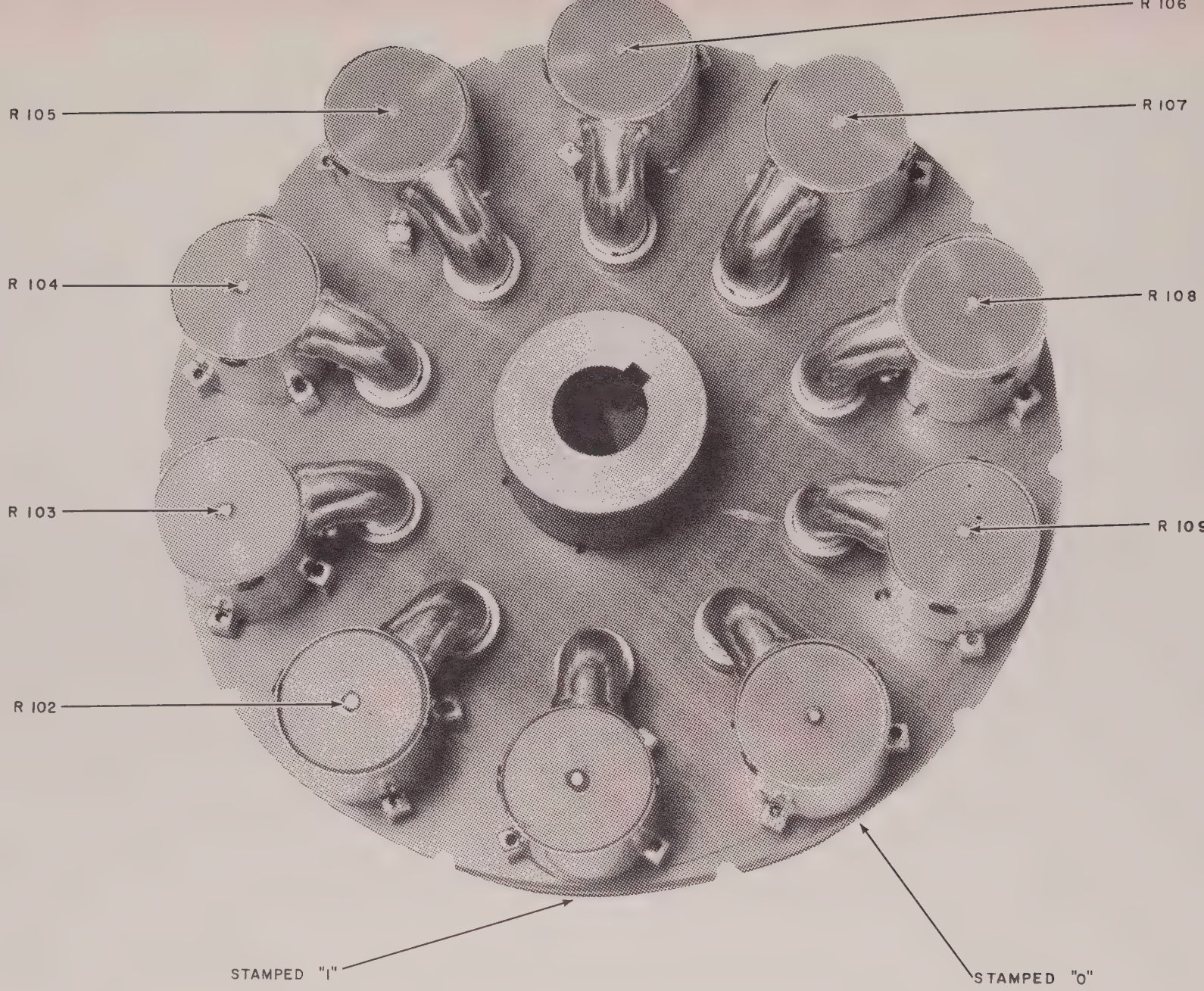

Top View TVI-T
Fig.-7




"A" Wheel TV1-T
Fig.-8




"B" Wheel TVI-T
Fig.-9




"C" Wheel TV1-T

Front View TVI-B
Fig.-11

Top View TVI-B
Fig.-12

## INSTRUCTIONS FOR ORDERING PARTS

All parts included herein are listed by manufacturer and manufacturer's designation, as well as by Holt Instrument Laboratory part numbers. Where both numbers are given, parts are obtainable from either source. There are, necessarily some special parts manufactured by or especially for Holt Instrument Laboratories. These parts have only a Holt number and are most easily obtained directly from Holt.

When ordering, refer to the instrument model and serial numbers. Also, include all the information from the table of replaceable parts.

Please note that under "Qty per end item" the total for the instrument is shown the first time that part is listed and includes all subsequent listings of that part.

Note that on starred items 5% parts are occasionally substituted because of availability.

## ELECTRONICS PARTS REFERENCE DESIGNATIONS

| | |
|---|---|
| CP | Adapter, connector |
| A | Amplifier (other than rotating) |
| E | Antenna; aerial |
| A | Assembly |
| AT | Attenuator |
| DS | Audible signaling device |
| T | Autotransformer |
| BY | Battery |
| E | Bimetallic strip |
| TB | Block, connecting |
| B | Blower, fan, motor, prime mover |
| TB | Board, terminal |
| CB | Breaker, circuit |
| DS | Buzzer |
| W | Cable |
| C | Capacitor |
| E | Cell, aluminum or electrolytic |
| V | Cell, light-sensitive, photo-emissive, or photo conductive |
| N | Chart |
| L | Choke |
| CB | Circuit breaker |
| M | Clock |
| HY | Coil, hybrid |
| L | Coil, induction, loading, relay operating, retardation, tuning |
| J | Connector, receptacle, electrical (with male, female or male & female contacts and designed to be mounted on a bulkhead, wall, chassis or panel) |
| P | Connector, plug, electrical (with male, female or male & female contacts, constructed to be affixed to the end of a cable, conduit, coaxial line, cord or wire) |
| K | Contactor (electrically operated) |
| S | Contactor (mechanically or thermally operated) |
| M | Counter (indicating device) |
| CR | Crystal detector |
| CR | Crystal diode |
| Y | Crystal, piezoelectric |
| CR | Crystal unit |
| S | Cutout, thermal |
| CR | Detector, crystal |
| DS | Device, indicating (except meter or thermometer) |
| V | Electron tube |
| B | Fan |
| FL | Filter |

| | |
|---|---|
| DS | Flasher |
| F | Fuse |
| X | Fuseholder |
| H | Hardware; bolts; nuts; screws |
| HR | Heater (element for thermostat, oven, etc.) |
| HY | Hybrid coil or junction |
| DS | Indicator |
| L | Inductor |
| MP | Interlock, mechanical |
| S | Interlock, safety, electrical |
| RT | Lamp, ballast |
| HR | Lamp, heating |
| DS | Lamp, illuminating |
| DS | Lamp, pilot |
| RT | Lamp, resistance |
| DS | Lamp, signal |
| X | Lampholder |
| LS | Loudspeaker |
| MP | Mechanical part |
| M | Meter |
| B | Motor |
| MP | Mounting (not in electrical circuit and not a socket) |

| | |
|---|---|
| N | Nameplate |
| Z | Network, general (where specific letters do not fit, when considered as a part) |
| AT | Pad |
| E | Part, miscellaneous electrical |
| R | Potentiometer |
| A | Power supply; source of power |
| J | Receptacle (Connector, fixed) |
| CR | Rectifier, crystal or metallic |
| VR | Regulator, voltage (except an electron tube) |
| MP | Reed, vibrating |
| K | Relay, (electrically operated contactor or switch) |
| R | Resistor |
| RT | Resistor, current regulating |
| R | Resistor, variable |
| R | Rheostat |
| CR | Selenium cell |
| E | Shield, electrical |
| R | Shunt |
| X | Socket |
| L | Solenoid |
| LS | Speaker; loudspeaker |
| TB | Strip, terminal |
| S | Switch (mechanically or thermally operated) |
| TP | Test point |
| RT | Thermistor |
| TC | Thermo-Couple |
| M | Thermometer |
| S | Thermostat |
| K | Timer |
| MT | Transducer |
| T | Transformer |
| Q | Transistor |
| V | Tube, electron |
| Z | Tuned circuit |
| CR | Varistor, asymmetrical |
| RV | Varistor, symmetrical |
| G | Vibrator, interrupting |
| DS | Visual signaling device |
| VR | Voltage regulator (except electron tube) |

## LIST OF CODE LETTERS USED IN THE TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURER

| | | |
|---|---|---|
| EO | Aerovox Corp. | New Bedford, Mass. |
| HH | Arrow-Hard & Hegeman | Hartford 6, Conn. |
| AM | Amphenol-Borg Electronics | Chicago, Ill. |
| BE | Beckman Instruments | Fullerton, Calif. |
| C | Centralab | Milwaukee, Wis. |
| OR | Cornish Wire Co. | New York 7, N.Y. |
| DA | Daven | Livingston, N.J. |
| EI | Electro Instruments, Inc. | San Diego, Calif. |
| LD | Eldema Corp. | El Monte, Calif. |
| EM | Arco-Elmenco | New York 13, N.Y. |
| EP | Electron Products | Pasadena, Calif. |
| HO | Hoffman Semiconductor | Evanston, Ill. |
| RC | International Resistance Co. | Philadelphia 8, Pa. |
| J | James Vibrapowr | Chicago, Ill. |
| LF | Little Fuse | Des Plaines, Ill. |
| LN | Leeds & Northrup Co. | Philadelphia, Pa. |
| AL | Mallory & Co. | Indianapolis 6, Ind. |
| NE | Northern Engineering Lab | Burlington, Wis. |
| HM | Ohmite | Skokie, Ill. |
| CA | Radio Corp. of America | Harrison, N.J. |
| SA | Sage Electronics | East Rochester, N.Y. |
| SP | Sprague | North Adams, Mass. |
| ST | Sarkes-Tarzian | Bloomington, Ill. |
| TA | Stancor | Chicago, Ill. |
| VP | Vacuum Products | Mt. Vernon, N.Y. |

TABLE OF REPLACEABLE PARTS

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Hdlt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 1 | C-200 | Capacitor, Fixed, Double Section Electrolytic, 40-40 MFD, 450 VDCW | MAL FP238 | 10501-406 | 1 |
| 2 | C-201 | Capacitor, Fixed, Electrolytic 40 MFD, 450 VDCW | MAL FP146 | 10511-406 | 2 |
| 3 | C-202 | Capacitor, Fixed, Electrolytic 40 MFD, 450 VDCW | MAL FP146 | 10511-406 | |
| 4 | C-203 | Capacitor, Fixed, Metallized Paper .1 MFD, 200 VDCW | AEO P-123Z-.1 | 10503-104 | 1 |
| 5 | C-204 | Capacitor, Fixed, Electrolytic 200 MFD, 10 VDCW | SP TE-1119.6-200 | 10531-207 | 1 |
| 6 | C-205 | Capacitor, Fixed, Metallized Paper .1 MFD, 400 VDCW | AEO P-123Z-.1 | 10503-104 | 1 |
| 7 | C-206 | Capacitor, Fixed, Disc. .01 MFD, 600 VDCW | C DD-103-.01 | 10508-103 | 2 |
| 8 | C-207 | Capacitor, Fixed, Epoxy Foil 1.0 MFD, 200 VDCW | EP M2-30 | 10513-105 | 1 |
| 9 | C-208 | Capacitor, Fixed, Electrolytic 150 MFD, 300 VDCW | MAL FP-131 | 10541-157 | 1 |
| 10 | C-209 | Capacitor, Fixed, Dur-Mica 2400 MMFD, 500 VDCW, ± 10% | EM DM-20-242J | 10506-242 | 1 |
| 11 | C-210 | Capacitor, Fixed Disc .01 MFD, 600 VDCW | C DD-103-.01 | 10508-103 | |
| 12 | CR-200 | Rectifier, Silicon, 750MA IN2482, 200 Max. PIV | ST F2 | 11401-001 | 6 |
| 13 | CR-201 | Rectifier, Silicon, 750MA IN2482, 200 Max. PIV | ST F2 | 11401-001 | |
| 14 | CR-202 | Rectifier, Silicon, 750MA IN2482, 200 Max. PIV | ST F2 | 11401-001 | |

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 15 | CR-203 | Rectifier, Silicon, 750MA IN2482,200 Max. PIV | ST F2 | 11401-001 | |
| 16 | CR-204 | Rectifier, Silicon, 750MA IN2482, 200 Max. PIV | ST F2 | 11401-001 | |
| 17 | CR-205 | Rectifier, Silicon, 750MA IN2482, 200 Max. PIV | ST F2 | 11401-001 | |
| 18 | CR-206 | Diode, Zener, Double Anode IN1782, 30 volts, MTD. IN Z-200 | HO IN1782 | 11404-002 | 1 |
| 19 | CR-207 | Diode, Zener, Double Anode IN429, 6.2 volts, MTD. IN Z-200 | HO IN429 | 11414-002 | 1 |
| 20 | DS-200 | Lamp, Neon, Miniature, Indicating Clear Lens, with 100K resistor | ELD Type 1EG3 | 13102-006 | 1 |
| 21 | DS-201 | See Leeds & Northrup manual for this part. | | | |
| 22 | F-200 | Fuse, SLO-BLO 3 AG, .5 AMP | LF 313.500 | 13103-501 | 1 |
| 23 | G-200 | Chopper, Instrument | J C-2342 | 12509-002 | 1 |
| 24 | J-100 | Part of Transfer Assembly | | 31456 | |
| 25 | J-300 | Receptacle, Polarized, chassis 3 contacts | AM 91PC3F | 12601-003 | 1 |
| 26 | PL-100 | Part of thermo-couple module | | 91240 | |
| 27 | PL-202 | Line cord, Nema approved 3 conductor | COR 3532 | 12612-003 | 1 |
| 28 | PL-300 | Connector, Male, Polarized 3 contacts | AM 91MC3M | 12602-003 | 1 |
| 29 | R-100 | Resistor, Fixed, Metal film Part of thermocouple module -psig Sealed unit | | 91240 | |

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 30 | R-102 | Resistor, Fixed, Metal film 142.5 Ohms, 1 watt ± .25% | DA 85IN-142.5 | 10000-141 | 1 |
| 31 | R-103 | Resistor, Fixed, Metal film 285 Ohms, 1 watt, ± .25% | DA 85IN-285 | 10000-281 | 1 |
| 32 | R-104 | Resistor, Fixed, Metal film 428 Ohms, 1 Watt, ± .25% | DA 85IN-428 | 10000-421 | 1 |
| 33 | R-105 | Resistor, Fixed, Metal film 570 Ohms, 1 watt, ± .25% | DA 851-570 | 10010-571 | 1 |
| 34 | R-106 | Resistor, Fixed, Metal film 714 Ohms, 1 watt, ± .25% | DA 851-714 | 10010-711 | 1 |
| 35 | R-107 | Resistor, Fixed, Metal film 857 Ohms, 1 watt ± .25% | DA 851-857 | 10010-851 | 1 |
| 36 | R-108 | Resistor, Fixed, Metal film 1000 Ohms, 1 watt, ± .25% | DA 851-1000 | 10010-102 | 1 |
| 37 | R-109 | Resistor, Fixed, Metal film 1142 Ohms, 1 watt, ± .25% | DA 851-1142 | 10010-112 | 1 |
| 38 | R-111 | Resistor, Fixed, Metal film 1285 Ohms, 2 watt, ± .25% | DA 852-1285 | 10020-122 | 1 |
| 39 | R-112 | Resistor, Fixed, Metal film 2720 Ohms, 2 watt, ± .25% | DA 852-2720 | 10020-272 | 1 |
| 40 | R-113 | Resistor, Fixed, Metal film 4140 Ohms, 2 watt, ± .25% | DA 852-4140 | 10020-412 | 1 |
| 41 | R-114 | Resistor, Fixed, Metal film 5570 Ohms, 2 watt, ± .25% | DA 852-5570 | 10020-552 | 1 |
| 42 | R-115 | Resistor, Fixed, Metal film 7000 Ohms, 2 watt, ± .25% | DA 852-7000 | 10020-702 | 1 |
| 4· | R-116 | Resistor, Fixed, Metal film 8440 Ohms, 2 watt, ± .25% | DA 852-8440 | 10020-842 | 1 |

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 44 | R-117 | Resistor, Fixed, Metal film 9860 Ohms, 2 watt, ± .25% | DA 852-9860 | 10020-982 | 1 |
| 45 | R-118 | Resistor, Fixed, Metal film 11280 Ohms, 2 watt, ± .25% | DA 852-11280 | 10020-113 | 1 |
| 46 | R-119 | Resistor, Fixed, Metal film 12700 Ohms, 2 watt, ± .25% | DA 852-12700 | 10020-123 | 1 |
| 47 | R-121 | Resistor, Fixed, Wire wound 14150 Ohms, 5 watt, ± 1% | SA SS-5W-14150 | 10030-143 | 1 |
| 48 | R-122 | Resistor, Fixed, Wire wound 28400 Ohms, 5 watt, ± 1% | SA SS-5W-28400 | 10030-283 | 1 |
| 49 | R-123 | Resistor, Fixed, Wire wound 42600 Ohms, 7 watt, ± 1% | SA SS-7W-42600 | 10040-423 | 1 |
| 50 | R-124 | Resistor, Fixed, Wire wound 57000 Ohms, 7 watt, ± 1% | SA SS-7W-57000 | 10040-573 | 1 |
| 51 | R-125 | Resistor, Fixed, Wire wound 71200 Ohms, 10 watt, ± 1% | SA SS-10W-71200 | 10050-713 | 1 |
| 52 | R-126 | Resistor, Fixed, Wire wound 85500 Ohms, 10 watt, ± 1% | SA SS-10W-85500 | 10050-853 | 1 |
| 53 | R-127 | Resistor, Fixed, Wire wound 99800 Ohms, 10 watt, ± 1% | SA SS-10W-99800 | 10050-993 | 1 |
| 54 | R-128 | Resistor, Fixed, Wire wound 114000 Ohms, 14 watt, special | | 31534 | 1 |
| 55 | R-129 | Resistor, Fixed, Wire wound 128200 Ohms, 14 watt, special | | 31535 | 1 |
| 56 | R-201 | Resistor, Fixed, composition 56 Ohms, 1/2 watt, ± 10% | OHM RC-20-56 | 10001-560 | 2 |
| 57 | R-202 | Resistor, Fixed, composition 470 Ohms, 1/2 watt, ± 10% | OHM RC-20-470 | 10001-471 | 2 |

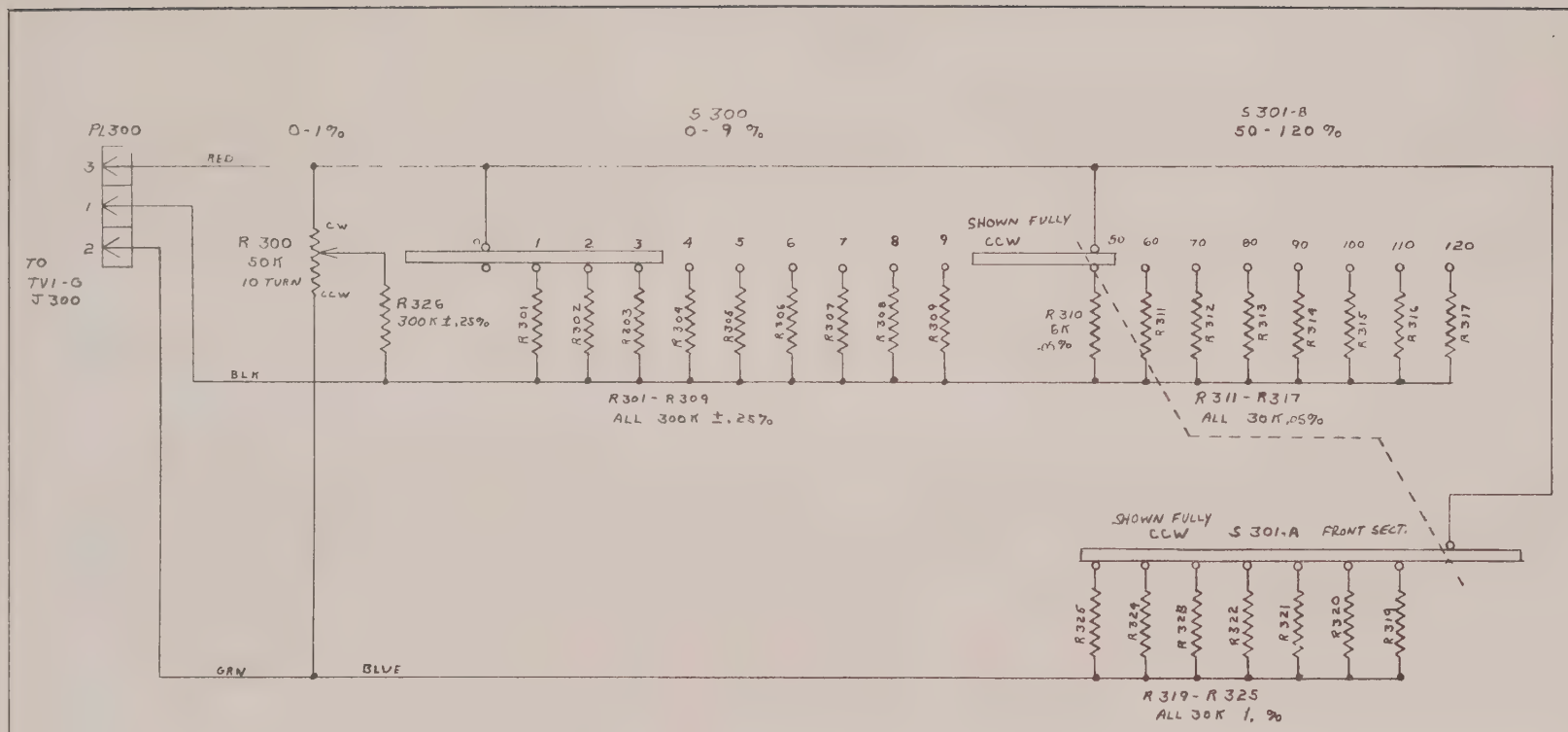
| Item | Circuit Ref. | | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|---|
| 58 | R-203 | | Resistor, Fixed, Composition Factory selected, ½ watt, ± 10% | OHM RC-20 | 10001 | |
| 59 | R-204 | | Resistor, Fixed, Wire wound 1000 Ohms, 5W, ± 10% | OHM Brown devil 1K | 10002-102 | 2 |
| 60 | R-205 | | Resistor, Fixed, Wire wound 1000 Ohms, 5W, ± 10% | OHM Brown devil 1K | 10002-102 | |
| 61 | R-206 | | Resistor, Fixed, Wire wound 10 Ohms, 10 watt, ± 10% | OHM Brown devil 10 | 10012-100 | 1 |
| 62 | R-207 | | Resistor, Fixed, Wire wound 3000 Ohms, 10 watt, ± 10% | OHM Brown devil 3K | 10012-302 | 1 |
| 63 | R-208 | | Resistor, Fixed, Wire wound 2000 Ohms, 5 watt, + 10% | OHM Brown devil 2K | 10002-202 | 1 |
| 64 | R-209 | | Resistor, Fixed, wire wound 3.5 K Ohms, 10 watt, ± 10% | OHM Brown devil 3.5K | 10012-352 | 1 |
| 65 | R-210 | | Resistor, Fixed, Wire wound 3000 Ohms, 5 watt, ± 10% | OHM Brown devil 3K | 10002-302 | 1 |
| 66 | R-211 | * | Resistor, Fixed, Composition 1 Meg Ohm, ½ watt, ± 10% | OHM RC-20-1M | 10001-105 | 2 |
| 67 | R-212 | | Resistor, Fixed, Composition 10 Meg Ohm, ½ watt, ± 10% | OHM RC-20-10M | 10001-106 | 1 |
| 68 | R-213 | | Resistor, Fixed, Composition. 470 Ohm, ½ watt, ± 10% | Ohm RC-20-470 | 10001-471 | |
| 69 | R-214 | | Resistor, Fixed, Composition 1.5 Meg Ohm, ½ watt, ± 10% | OHM RC-20-1.5M | 10001-155 | 1 |

| Item | Circuit Ref. | | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|---|
| 70 | R-215 | | Resistor, Fixed, Composition<br>10 K Ohms, ½ watt, ± 10% | OHM<br>RC-20-10K | 10001-103 | 1 |
| 71 | R-216 | | Resistor, Fixed, Composition<br>220 K Ohms, ½ watt, ± 10% | OHM<br>RC-20-220K | 10001-224 | 1 |
| 72 | R-217 | | Resistor, Fixed, Composition<br>390 K Ohms, ½ watt, ± 10% | OHM<br>RC-20-390K | 10001-394 | 2 |
| 73 | R-218 | | Resistor, Fixed, Composition<br>390 K Ohms, ½ watt, ± 10% | OHM<br>RC-20-390 | 10001-394 | |
| 74 | R-219 | * | Resistor, Fixed, Composition<br>1 Meg Ohm, ½ watt, ± 10% | OHM<br>RC-20-1M | 10001-105 | |
| 75 | R-220 | | Resistor, Fixed, Composition<br>1.8 Meg Ohm, ½ watt, ± 10% | OHM<br>RC-20-1.8M | 10001-185 | 1 |
| 76 | R-221 | | Resistor, Fixed, Deposited Carbon<br>2.7 K Ohms, ½ watt, ± 1% | IRC<br>DCC-RN20X-2.7K | 10003-272 | 1 |
| 77 | R-222 | | Resistor, Variable Composition<br>100 K Ohms, 2 watt, ± 10% | OHM<br>CLU-1041 | 10005-104 | 1 |
| 78 | R-223 | | Resistor, Fixed, Deposited Carbon<br>4.3 K Ohms, ½ watt, ± 1% | IRC<br>DCC-RN20X-4.3K | 10003-432 | 1 |
| 79 | R-224 | | Resistor, Fixed, Composition<br>47 K OHMs, 1 watt, ± 10% | OHM<br>RC-32-47K | 10031-473 | 1 |
| 80 | R-225 | | Resistor, Fixed, Composition<br>3.9 K Ohms, ½ watt, ± 10% | OHM<br>RC-20-3.9K | 10001-392 | 1 |
| 81 | R-226 | | Resistor, Variable, Wire wound<br>10 K Ohms, 3 turn precision | BE<br>Model C, 3T-10K | 10015-103 | 1 |
| 82 | R-227 | | Resistor, Fixed, Composition<br>56 Ohms, ½ watt, ± 10% | OHM<br>RC-20-56 | 10001-560 | |
| 83 | R-228 | | Resistor, Fixed, Composition<br>Factory-selected, ½ watt, ± 10% | OHM<br>RC-20 | 10001 | |

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 84 | R-229 | Resistor, Fixed, Composition 100 Ohms, ½ watt, ± 10% | OHM RC-20-100 | 10001-101 | 1 |
| 85 | R-300 | Resistor, Variable, Wire wound 50 K Ohms, 10 turn, precision | BE Helipot, 10T-50K | 10025-503 | 1 |
| 86 | R-301 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | 10 |
| 87 | R-302 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 88 | R-303 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 89 | R-304 | Resistor, Fixed, Metal film 300 K OHMs, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 90 | R-305 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 91 | R-306 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 92 | R-307 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 93 | R-308 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 94 | R-309 | Resistor, Fixed, Metal film 300 K Ohms, ½ watt, ± .25% | DA 850-300K | 10004-304 | |
| 95 | R-310 | Resistor, Fixed, Wire wound 6 K Ohms, Jelly Bean, .05% | EI 286-6K | 10022-602 | 1 |
| 96 | R-311 | Resistor, Fixed, Wire wound 30 K Ohms, Jelly Bean, .05% | EI 286-30 K | 10022-303 | 7 |
| 97 | R-312 | Resistor, Fixed, Wire wound 30 K Ohms, Jelly Bean, .05% | EI 286-30K | 10022-303 | |

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 98 | R-313 | Resistor, Fixed, Wire wound<br>30 K Ohms, Jelly Bean, .05% | EI<br>286-30K | 10022-303 | |
| 99 | R-314 | Resistor, Fixed, Wire wound<br>30 K Ohms, Jelly Bean, .05% | EI<br>286-30K | 10022-303 | |
| 100 | R-315 | Resistor, Fixed, Wire wound<br>30 K Ohms, Jelly Bean, .05% | EI<br>286-30K | 10022-303 | |
| 101 | R-316 | Resistor, Fixed, Wire wound<br>30 K Ohms, Jelly Bean, .05% | EI<br>286-30K | 10022-303 | |
| 102 | R-317 | Resistor, Fixed, Wire wound<br>30 K Ohms, Jelly Bean, .05% | EI<br>286-30K | 10022-303 | |
| 103 | R-319 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | 6 |
| 104 | R-320 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | |
| 105 | R-321 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | |
| 106 | R-322 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | |
| 107 | R-323 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | |
| 108 | R-324 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | |
| 109 | R-325 | Resistor, Fixed, Deposited carbon<br>30 K Ohms, $\frac{1}{2}$ watt, $\pm$ 1% | AEO<br>CP$\frac{1}{2}$-30K | 10013-303 | |
| 110 | R-326 | Resistor, Fixed, Metal film<br>300 K Ohms*, $\frac{1}{2}$ watt, $\pm$ .25%<br>* Adj. slightly at factory. | DA<br>850-300K | 10004-304 | |
| 111 | S-200 | Switch, SPST, bat handle | AHH<br>20994-LH | 12004-101 | 1 |

| Item | Circuit Ref. | Description | Mfr. & Mfr. Designation | Holt Part No. | Qty per End Item |
|---|---|---|---|---|---|
| 112 | S-201 | Galvonometer key, guarded Push button | LN 031165 | 12005-201 | 2 |
| 113 | S-202 | Galvonometer key, guarded Push button | LN 031165 | 12005-201 | |
| 114 | S-300 | Switch, rotary, 10 position | | 31536 | 1 |
| 115 | S-301 | Switch, rotary, 8 position | | 31537 | 1 |
| 116 | T-200 | Transformer, power, 115 V primary 6.3 V., 460 V.C.T., Secondarys 60 cps. | STA PC 8418 | 11602 | 1 |
| 117 | T-201 | Transformer, Step down See Leeds & Northrup manual | | | |
| 118 | TC-100 | Part of thermocouple module assy. | | 91240 | |
| 119 | TC-200 | Thermocouple, Insulated, 2 MA rated VP Couple-chromel P & copper nickle, 7 MV. | | 13104-020 | 1 |
| 120 | V-200 | Vacuum tube, electron | RCA 6X5 | 11000 | 1 |
| 121 | V-201 | Vacuum tube, electron | RCA 0B2 | 11001 | 2 |
| 122 | V-202 | Vacuum tube, electron | RCA 0A2 | 11011 | 1 |
| 123 | V-203 | Vacuum tube, electron | RCA 0B2 | 11001 | |
| 124 | V-204 | Vacuum tube, electron | RCA 12AX7 | 11005 | 1 |
| 125 | V-205 | Vacuum tube, electron | RCA 6C4 | 11021 | 1 |
| 126 | Z-200 | Oven, w/CR-206 and CR-207 | NE | 13105-550 | 1 |

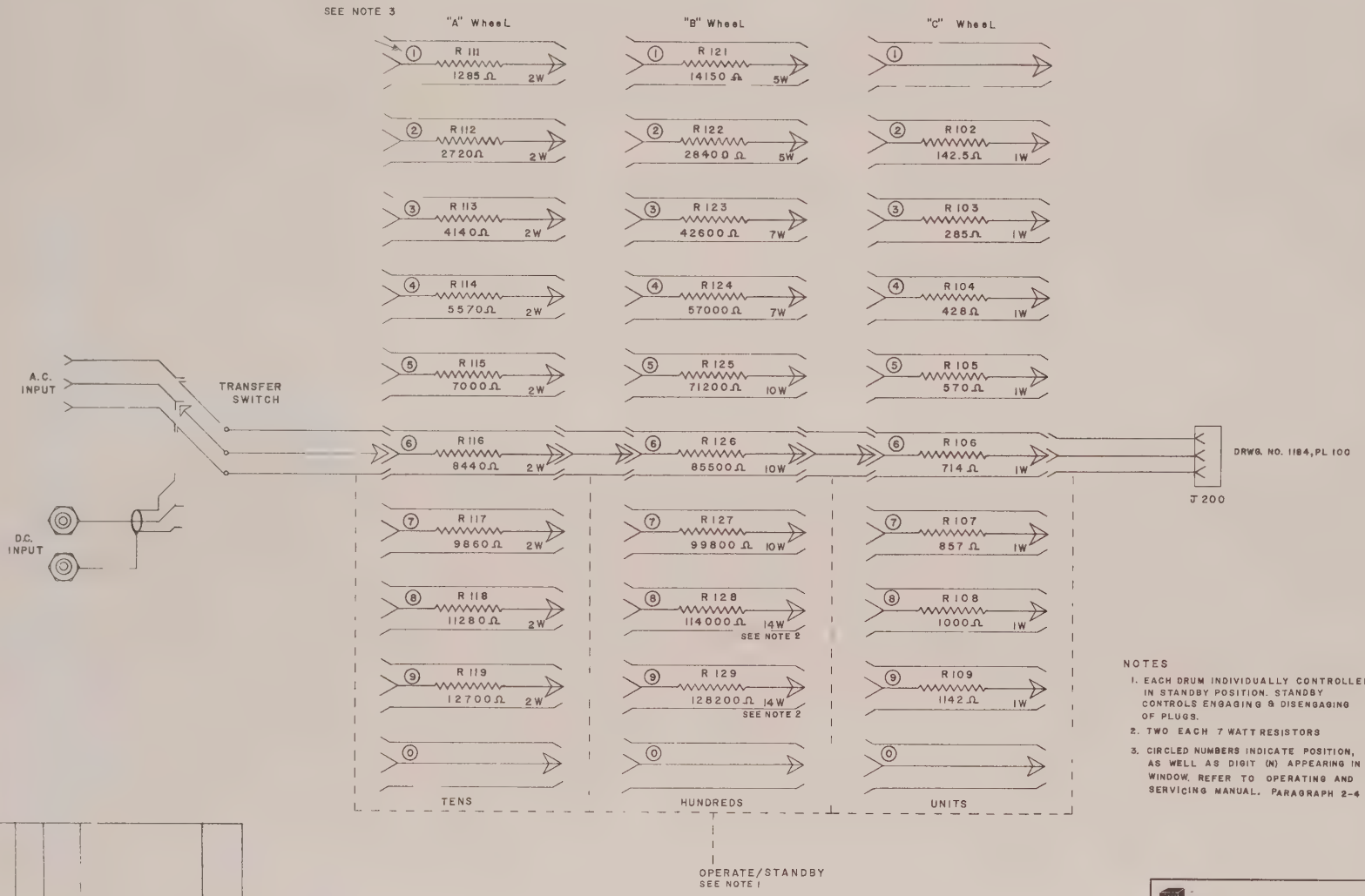



NOTE: S 301 SHOWN IN 50% POSITION

| | | | | |
|---|---|---|---|---|
| A | 7011 | 1-10-61 | REMOVE R-318 | RDR |
| CHN | XC | DATE | DESCRIPTION | ENG DRF |

HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

| | | | |
|---|---|---|---|
| TITLE | THERMAL BALANCE UNIT | | |
| MAT'L | DATE 9-12-60 | MODEL | TV1-B |
| FIN. | APPROVED DJS | DRAWING NO. | CHNG |
| TOLERANCE UNLESS NOTED FRACT. DEC. SCALE | DRFT RLD | 1356 | A |




NOTES

1. EACH DRUM INDIVIDUALLY CONTROLLED IN STANDBY POSITION. STANDBY CONTROLS ENGAGING & DISENGAGING OF PLUGS.
2. TWO EACH 7 WATT RESISTORS
3. CIRCLED NUMBERS INDICATE POSITION, AS WELL AS DIGIT (N) APPEARING IN WINDOW. REFER TO OPERATING AND SERVICING MANUAL. PARAGRAPH 2-6

| CHN | XC | DATE | DESCRIPTION | drt | eng |
|---|---|---|---|---|---|
| A | 7612 | 1-16-61 | ADD PARTS LIST, CHG R1 | | |

HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

| | |
|---|---|
| MAT'L | |
| FIN | |
| TOLERANCE UNLESS NOTED | FRACT DEC ANG |
| SCALE | |
| TITLE | TV-1 TRANSFER UNIT |
| DATE | 12-17-60 |
| MODEL | TV-1T |
| APPROVED | D.H.S. |
| DRFT | RLD |
| DRAWING NO | 1403 |
| | A |

T 200

V 200
6X5

R 204
1K
5W

C 200-A
40

F 200
.5A

S 200

DS 200

C 201
40

CR 210

CR 211

R 206
10
10W

R 207
3K
10W

P 202

115 VAC
60 ~

DS 201

T201

V 200

V 204

V 205

TO
CHOPPER
DRIVE

To PIN 2

To PIN 1

R 211
1M

GALVO

FRONT

GUARD

TC
COMMON

R 201
56

G 200

WHITE

RED

GRN

BLK

COARSE
S 201

FINE
S 202

R 202
470

GALVO CONTROL

BLACK

TO 6.3 VAC

WHITE

TO
TVI-T
J 100

J-4

Z201

| CHG | XC | DATE | DESCRIPTION | DRFT |
|---|---|---|---|---|
| A | | 5-27-60 | ADD SHIELDING | RD |
| B | | 8-22-60 | SCHEMATIC RE-DRAWN | RD |
| C | 7002 | 10-6-60 | REV. ZENER PIN NOS | DS |
| D | 7004 | 10-10-60 | C-203, 208, 209 - R-215 | JMK |
| E | – | 11-[illegible] | V-205 6AB4 TO 6C4 | |
| F | – | 12-27-60 | ASSIGNING REF NO.'S TO ALL COMPONENTS & T.P. | JMK |
| G | 7008 | 1-10-61 | R 217, 218, FROM 360 K TO 390 K | RLD |
| H | 7010 | 1-10-61 | C 208 300 MFD TO 150 MFD | RD |
| I | 7013 | 1-10-61 | LEFT T.C. TERMINALS | DS |
| J | 7029 | 7-10-61 | J-1 WAS 2.7K J-2 WAS 4.3K | |
| J-3 | 7031 | 7-21-61 | REMOVE R 227 5% | |
| J-4 | 7032 | 7-21-61 | [illegible] | |
| J-5 | 7033 | 7-28-61 | RECTIFIER [illegible] | |
| J-6 | 7034 | 8-1-61 | DELETE J-200 ADDED | DS |
| J7 | 7038 | 9-5-61 | REVISED SCHEMATIC TO SHOW [illegible] | |
| K | 7041 | 10-5-61 | ADDED K-1 | |
| | | | | |

+255 V

R 205 1K 5W

V 201 0B2

C 200-A 40

V 202 0A2

.01 C 210

V 203 0B2

C 202 40

Z 200

CR 207 IN429

CR-206 IN1782

R 208 2K 5W

R 209 3.5K 10W

R 210 3K 5W

-6.2 V

TO TV-B P 300

J 300

V 204 12AX7

C 203 .1

R 216 220K

R 217 390K

R 218 390K

C 208 150

R 224 47K 1W

R 225 3.9K

R 222 100K COARSE

R 223 4.32K ±1% (V-2)

R 226 10K FINE

CCW

C-209 2400mmf

C 205 .1

V 205 6C4

R 219 1M

C 206 .01

R 220 1.8M

TOP CAP

R 212 10M

R 213 470

R 214 1.5M

R 215 10K

C 204 200 10V

C 207 1.0

R 221 2.74K ±1% (V-1)

P 200 (J-6)

TP 201

TP 202

TP 205

J-200

BLK

WHT

WHITE

RED

GRN

GREEN

TRANSFER THERMO ELEMENT

TEMP. COMP. THERMO ELEMENT

A 100 Ω

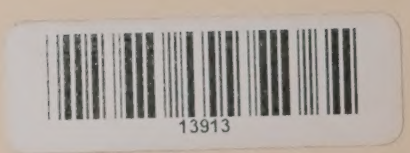
(J-5)

| | | | |
|---|---|---|---|
| MAT'L | | DATE 8-22-60 | MODEL TV1-G |
| FIN | | APPROVED D.S. | DRAWING NO 31184 |
| TOLERANCE UNLESS NOTED | FRACT DEC | SCALE | DRFT RLD |

HOLT INSTRUMENT LABORATORIES

OCONTO WISCONSIN

TITLE SCHEMATIC


13913